Appendix E: Preliminary Geotechnical Investigation
E-1: Preliminary Geotechnical Investigation Report
Preliminary Geotechnical Investigation Report, 
Addition to Terrace Apartments, 
200 City Boulevard West 
Orange, California 

Prepared For 
DOMINO REALTY MANAGEMENT CO. 

November 22, 2017 

GMU Project No. 17-176-00
TRANSMITTAL

DOMINO REALTY MANAGEMENT CO.          DATE: November 22, 2017
9990 Santa Monica Boulevard
Beverly Hills, CA 90212

PROJECT: 17-176-00

ATTENTION: Mr. Sidh Solanki

SUBJECT: Preliminary Geotechnical Investigation Report, Addition at Terrace
          Apartments, 200 City Boulevard West, Orange, California

DISTRIBUTION:

Electronic copy to addressee

cc: Van Tilburg, Banvard & Soderbergh (electronic copy)
   Attn: Mr. Roger Wolf
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>PURPOSE</td>
<td>1</td>
</tr>
<tr>
<td>SCOPE</td>
<td>1</td>
</tr>
<tr>
<td>LOCATION AND DESCRIPTION</td>
<td>2</td>
</tr>
<tr>
<td>PROPOSED IMPROVEMENTS</td>
<td>2</td>
</tr>
<tr>
<td>SUBSURFACE EXPLORATION</td>
<td>2</td>
</tr>
<tr>
<td>LABORATORY TESTING</td>
<td>3</td>
</tr>
<tr>
<td>GEOLOGIC FINDINGS</td>
<td>3</td>
</tr>
<tr>
<td>REGIONAL GEOLOGIC SETTING</td>
<td>3</td>
</tr>
<tr>
<td>Geologic Formations</td>
<td>3</td>
</tr>
<tr>
<td>GROUNDWATER</td>
<td>3</td>
</tr>
<tr>
<td>GEOLOGIC HAZARDS</td>
<td>4</td>
</tr>
<tr>
<td>FAULTING AND SEISMICITY</td>
<td>4</td>
</tr>
<tr>
<td>LIQUEFACTION AND SEISMIC SETTLEMENT</td>
<td>4</td>
</tr>
<tr>
<td>Liquefaction</td>
<td>4</td>
</tr>
<tr>
<td>Secondary Seismic Hazards</td>
<td>4</td>
</tr>
<tr>
<td>Seismic Settlement</td>
<td>5</td>
</tr>
<tr>
<td>LANDSLIDES</td>
<td>5</td>
</tr>
<tr>
<td>TSUNAMI, SEICHE, AND FLOODING</td>
<td>5</td>
</tr>
<tr>
<td>GEOTEchnical ENGINEERING FINDINGS</td>
<td>5</td>
</tr>
<tr>
<td>SOIL EXPANSION</td>
<td>5</td>
</tr>
<tr>
<td>SOIL CORROSION</td>
<td>5</td>
</tr>
<tr>
<td>PRELIMINARY PERCOLATION TESTING</td>
<td>6</td>
</tr>
<tr>
<td>EXCAVATION CHARACTERISTICS</td>
<td>7</td>
</tr>
<tr>
<td>Rippability</td>
<td>7</td>
</tr>
<tr>
<td>CONCLUSIONS</td>
<td>7</td>
</tr>
<tr>
<td>RECOMMENDATIONS</td>
<td>8</td>
</tr>
<tr>
<td>GENERAL SITE PREPARATION AND GRADING</td>
<td>8</td>
</tr>
<tr>
<td>General</td>
<td>8</td>
</tr>
<tr>
<td>Clearing and Grubbing</td>
<td>8</td>
</tr>
<tr>
<td>Corrective Grading</td>
<td>8</td>
</tr>
<tr>
<td>Temporary Excavations</td>
<td>10</td>
</tr>
<tr>
<td>Temporary Shoring</td>
<td>11</td>
</tr>
<tr>
<td>STRUCTURE SEISMIC DESIGN</td>
<td>14</td>
</tr>
<tr>
<td>FOUNDATION DESIGN AND CONSTRUCTION – AT-GRADE TOWNHOMES</td>
<td>15</td>
</tr>
<tr>
<td>General</td>
<td>15</td>
</tr>
<tr>
<td>General Foundation Design Parameters – At-Grade Townhomes</td>
<td>15</td>
</tr>
<tr>
<td>FOUNDATION DESIGN AND CONSTRUCTION – SUBTERRANEAN LEVELS</td>
<td>17</td>
</tr>
<tr>
<td>General</td>
<td>17</td>
</tr>
<tr>
<td>General Foundation Design Parameters – Conventional Spread/Continuous Footings</td>
<td>17</td>
</tr>
<tr>
<td>General Foundation Design Parameters – Mat Foundation</td>
<td>19</td>
</tr>
<tr>
<td>Geopiers or Equivalent Gravel Piers</td>
<td>19</td>
</tr>
<tr>
<td>BASEMENT WALLS</td>
<td>20</td>
</tr>
</tbody>
</table>
Mr. Sidh Solanki, DOMINO REALTY MANAGEMENT CO.
Preliminary Geotechnical Investigation Report, Addition to Terrace Apartments, 200 City Boulevard West, Orange, California

General ........................................................................................................................................20
Foundation Recommendations ..................................................................................................20
Lateral Earth Pressure .................................................................................................................20
Dynamic Lateral Load ................................................................................................................20
Drainage .......................................................................................................................................20
Waterproofing .............................................................................................................................21
STRUCTURAL CONCRETE ........................................................................................................21
FERROUS METAL CORROSION PROTECTION ...................................................................21
MOISTURE VAPOR TRANSMISSION .......................................................................................22
Moisture Vapor Retarder ..............................................................................................................22
SURFACE DRAINAGE ..................................................................................................................23
UTILITY TRENCH BACKFILL CONSIDERATIONS ..................................................................23
General .........................................................................................................................................23
Pipe Zone (Bedding and Shading) ...............................................................................................23
Trench Backfill .............................................................................................................................24
ASPHALT CONCRETE PAVEMENT THICKNESS RECOMMENDATIONS ............................24
CONCRETE PAVEMENT THICKNESS RECOMMENDATIONS ...............................................25
SITE INFILTRATION ......................................................................................................................25
CONCRETE FLATWORK DESIGN ............................................................................................26
PLAN REVIEW / GEOTECHNICAL TESTING DURING GRADING / FUTURE REPORT ..............27
Plan Review ....................................................................................................................................27
Geotechnical Testing ..................................................................................................................27
Future Report ...............................................................................................................................27
LIMITATIONS ..............................................................................................................................28
CLOSURE ......................................................................................................................................29
REFERENCES .................................................................................................................................30

PLATES

Plate 1 -- Location Map
Plate 2 -- Drill Hole and Percolation Locations Map

APPENDICES

APPENDIX A: Geotechnical Exploration Procedures, Drill Hole Logs, and Cone Penetration Testing Data by GMU
APPENDIX A-1: Cone Penetration Testing Data by GMU
APPENDIX B: Geotechnical Laboratory Procedures and Test Results by GMU
APPENDIX C: Liquefaction Analysis
APPENDIX D: Percolation Test Result
INTRODUCTION

PURPOSE

This report presents the results of our preliminary geotechnical engineering evaluation performed for the proposed additions to the Terrace Apartments project located at 200 City Boulevard West, in the City of Orange, California. The purpose of this study is to evaluate the subsurface conditions at the site and to provide preliminary geotechnical recommendations related to the design and construction of the proposed structures. The preliminary geotechnical recommendations should be reviewed when structural loads and wall/column locations become available.

SCOPE

The scope of our services, as outlined in our August 18, 2017 proposal is as follows:

1. Reviewed the reference conceptual plans dated February 2, 2017 (references listed on Page 30).

2. Marked eleven (11) truck-mounted, hollow-stem-auger (HSA) drill holes, and seven (7) cone penetration testing (CPT) soundings, coordinated with Domino Realty Management Co., and contacted Underground Service Alert (USA/Dig Alert) in order to provide advanced notification of the subsurface drill holes and CPT’s planned within the subject site.

3. Performed a field subsurface exploration program consisting of:
   - Advancing a total of eleven (11) HSA drill holes to a maximum depth of 71.5 feet below the existing ground surface (in order to classify the subsurface material and obtain representative samples for laboratory testing to be utilized during design).
   - Utilizing four of the eleven HSA drill holes to perform percolation testing.
   - Performing seven (7) CPT soundings to a maximum depth of 75 feet below the existing ground surface.
   - Logging of all field exploration work and obtaining bulk, drive, and SPT soil samples for geotechnical laboratory testing.

4. Performed laboratory testing on soil samples obtained from the HSA drill holes. Testing included moisture and density, Atterberg limits, particle size distribution, maximum density and optimum moisture content, direct shear testing, consolidation, R-value, and full chemical analysis.

5. Interpreted and evaluated the acquired field and laboratory data. Performed geotechnical engineering analysis to evaluate potential geological hazards and develop preliminary geotechnical conclusions and recommendations that are contained herein.
6. Prepared this geotechnical investigation report.

LOCATION AND DESCRIPTION

The site is currently occupied by the existing Terrace Apartments, and is bound by Lewis Street and existing asphalt-paved parking lot on the west, by an existing asphalt-paved parking lot on the north, by an existing asphalt-paved parking lot, City Boulevard West and The City Way East on the east, and asphalt-paved parking lot on the south. The general location of the project is shown on Plate 1 – Location Map.

The site relatively flat and consist of existing three-story, above-grade apartment homes over one-level of subterranean parking. The site is also occupied by asphalt-concrete pavement, car ports, trees and planter areas.

PROPOSED IMPROVEMENTS

It is our understanding that the proposed project will consist of development of three (3) four-story buildings over two (2) story of subterranean parking structure and twenty eight (28) two-story at-grade three (3) story townhomes. Two of the four story structures are planned to be constructed adjacent to City Boulevard West and the third four-story building is planned to be constructed adjacent to Lewis Street. The townhomes are planned to be constructed along the north and south side of the property. In addition, it is our understanding the project will also include construction of new asphalt-concrete pavement and associated site work. The site layout and our field investigation locations are shown on Plate 2 – Geotechnical Map.

SUBSURFACE EXPLORATION

GMU conducted a subsurface exploration program to evaluate the soil conditions within the project limits. A total of eleven (11) exploratory drill holes and seven (7) CPT soundings were performed which consisted of the following:

- Eleven (11) hollow-stem-auger exploratory drill holes to a maximum depth of 71.5 feet below the existing ground surface in order to determine site specific subsurface geologic and groundwater conditions and to obtain bulk and drive samples for geotechnical testing.
- Seven (7) CPT soundings to a maximum depth of 75 feet below the existing ground surface.

The drill holes were logged by our staff engineer and samples were collected and transported to our facility for observation and testing. The drill holes and CPT locations are shown on Plate 2 –
Drill Hole and Percolation Locations Map. Drill hole logs are contained in Appendix A and CPT reports are presented in Appendix A-1.

LABORATORY TESTING

Laboratory testing for the subject investigation was performed on samples collected during our field investigation and included the following tests:

- In-place moisture and density
- Maximum density and optimum moisture content
- Particle size distribution
- Atterberg limits
- Consolidation tests
- Direct shear tests
- R-value
- Corrosion series testing (sulfate content, chloride content, pH, and soil resistivity)

The results of our laboratory testing are summarized on Table B-1 included in Appendix B – Geotechnical Laboratory Procedures and Test Results.

GEOLOGIC FINDINGS

REGIONAL GEOLOGIC SETTING

The site is located within the Los Angeles Basin within the Peninsular Range Province. According to the geologic map of the Santa Ana (CGS, 2006), the project site is underlain by younger alluvial fan deposits (Qyf) that are typically comprised of sand, clay, silts and gravel.

Geologic Formations

Earth materials encountered during our subsurface investigation consist of approximately two to three feet of artificial fill (Qaf) overlaying the alluvial fan deposits (Qyf) extending to the total depth of exploration. In general, the artificial fill consists of damp to moist, loose to medium dense, silty sand material. The alluvial fan deposits (Qyf) consists of moist, loose to dense sands, and moist to very moist, firm to stiff, clay and silts material.

GROUNDWATER

Groundwater was not observed during our exploration to a maximum depth of 71.5 feet below the existing grade. The historical high depth to groundwater is reportedly 50 feet below the existing grade at the project site (CDMG 2001). Groundwater conditions may vary across the site due to
stratigraphic and hydrologic conditions, and may change over time as a consequence of seasonal and meteorological fluctuations, or activities by humans at this site and nearby sites. However, based on the above findings, groundwater is unlikely to impact the proposed development.

GEOLOGIC HAZARDS

FAULTING AND SEISMICITY

The site is not located within an Alquist-Priolo Earthquake Fault Zone, and no known active faults are shown on the reviewed geologic maps crossing the site, however, the site is located in the seismically active region of Southern California. The nearest known active faults are the San Joaquin hills and the Puente Hills (Coyote Hills) systems, which are located approximately 6 miles from the site and capable of generating a maximum earthquake magnitude (Mw) of 6.9 and 7.1, respectively.

Given the proximity of the site to these and numerous other active and potentially active faults, the site will likely be subject to earthquake ground motions in the future. A site PGA_M of 0.53g was calculated for the site in conformance with the 2016 CBC. This PGA_M is primarily dominated by earthquakes with a mean magnitude of 6.6 at a mean distance of 9 miles from the site using the USGS 2014 Interactive Deaggregation website.

LIQUEFACTION AND SEISMIC SETTLEMENT

Liquefaction

Based on our review of the State of California Official Map of Seismic Hazard for the Anaheim Quadrangle, the site is not located within a zone of required investigation for liquefaction. In addition, based on the lack of shallow groundwater, relatively uniform soil stratum across the site, and our liquefaction analysis, it is our professional opinion that the liquefaction potential at the site is very low.

Secondary Seismic Hazards

Seismically induced dry sand settlement is the ground settlement due to densification of loose, dry, cohesionless soils during strong earthquake shaking. Based on our secondary seismic hazard analysis, it is our professional opinion that the potential for seismically induced dry-sand settlement is low to moderate.
Seismic Settlement

Based on our seismic settlement analysis results and review of overall soil conditions, we recommend that an average total seismic settlement of less than ½ inch with differential settlement of less than ¼ inch over a 30 feet span be used for the structural design of the at-grade townhomes.

LANDSLIDES

Based on our review of available geologic maps, literature, topographic maps, aerial photographs, and our subsurface evaluation, no landslides or related features underlie or are adjacent to the subject site. Due to the relatively level nature of the site and surrounding areas, the potential for landslides to occur at the project site is considered negligible.

TSUNAMI, SEICHE, AND FLOODING

The site is not located on any State of California – County of Orange Tsunami Inundation Map for Emergency Planning. The potential for the site to be adversely impacted by earthquake-induced tsunamis is considered to be negligible because the site is located several miles inland from the Pacific Ocean coast at an elevation exceeding the maximum height of potential tsunami inundation.

The potential for the site to be adversely impacted by earthquake-induced seiches is considered to be negligible due to the lack of any significant enclosed bodies of water located in the vicinity of the site.

GEOTECHNICAL ENGINEERING FINDINGS

SOIL EXPANSION

Based on our evaluation and experience with similar material types, the sandy soils encountered near the ground surface at the site exhibit a very low expansion potential, however, the clay soils encountered at the basement level exhibit a low to medium expansion potential.

SOIL CORROSION

Based on laboratory test results for pH, soluble chlorides, sulfate, and minimum resistivity of the site soils obtained during our subsurface investigation, the on-site soils should be considered to have the following:

- A moderate sulfate exposure to concrete per ACI 318-14, Table 19.3.2.1
A low to high minimum resistivity indicating conditions that are severely corrosive to ferrous metals.

A chloride content of up to 2064 ppm (severely corrosive to ferrous metals).

Metal structures which will be in direct contact with the soil (i.e., underground metal conduits, pipelines, metal sign posts, etc.) and/or in close proximity to the soil (wrought iron fencing, etc.) may be subject to corrosion. The use of special coatings or cathodic protection around buried metal structures has been shown to be beneficial in reducing corrosion potential. Corrosion of ferrous metal reinforcing elements in structural concrete should be reduced by increasing the thickness of concrete cover and the use of the recommended maximum water/cement ratio for concrete. The results of the laboratory chemical tests performed within the site are presented in Table B-1 in Appendix B.

The laboratory testing program performed for this project does not address the potential for corrosion to copper piping. In this regard, a corrosion engineer should be consulted to perform more detailed testing and develop appropriate mitigation measures (if necessary). The above discussion is provided for general guidance in regards to the corrosiveness of the on-site soils to typical metal structures used for construction. Detailed corrosion testing and recommendations for protecting buried ferrous metal and/or copper elements are beyond our purview. If detailed recommendations are required, a corrosion engineer should be consulted to develop appropriate mitigation measures.

PRELIMINARY PERCOLATION TESTING

Four (4) preliminary percolation tests were performed in general conformance with the Santa Ana Regional Water Quality Control Board Technical Guidance Document (TGD), Appendices dated March 2011. The “Shallow Percolation” test procedure contained in Section VII.3.8 was utilized. The percolation borings were drilled to depths ranging from 5 to 11 feet below the existing grade using a hollow-stem-auger, truck-mounted drill rig. The calculated infiltration rates are presented in Table 1 below. We note that that the project civil engineer should apply a safety factor to the infiltration rates presented below in accordance with the TGD manual.

<table>
<thead>
<tr>
<th>Drill Hole</th>
<th>Depth Below Finish Grade (feet)</th>
<th>Infiltration Rate (inch/hour)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DH-8</td>
<td>5.20</td>
<td>4.34</td>
</tr>
<tr>
<td>DH-9</td>
<td>11.0</td>
<td>3.86</td>
</tr>
<tr>
<td>DH-10</td>
<td>10.7</td>
<td>20.00</td>
</tr>
<tr>
<td>DH-11</td>
<td>5.0</td>
<td>20.06</td>
</tr>
</tbody>
</table>
The preliminary percolation test hole locations are shown on the attached Drill Hole and Percolation Locations Map, Plate 2. The results of the percolation testing are summarized in Appendix D of this report and site infiltration recommendations are presented later in this report.

EXCAVATION CHARACTERISTICS

Rippability

The majority of the soil materials underlying the site can be excavated with scrapers and other conventional grading equipment.

CONCLUSIONS

Based on our geotechnical findings, the following is a summary of our conclusions:

1. The project area is not underlain by any known active faults.
2. Groundwater is not expected to be encountered and is not anticipated to have a significant impact on the proposed development.
3. The site is not subject to liquefaction, however, there is a potential for minor dry seismic settlement to be incorporated into the design.
4. Site soils within the at-grade foundation influence zone are anticipated to have a low expansion potential based on our recent laboratory test results and local experience, however, site clayey soils within the below-grade foundation influence zone are anticipated to have a low to medium expansion potential. Recommendations for the proposed developments are based on a “low to medium” expansive condition.
5. Corrosion testing indicates that the on-site soils have a moderate sulfate exposure and are severely corrosive to buried ferrous metals and reinforcing steel. Consequently, any metal exposed to the soil shall be protected. In addition, due to high levels of chlorides, steel reinforcement will require proper concrete cover.
6. Based on our percolation testing and calculated infiltration rates, the site soils in the upper 5 to 10 feet are deemed feasible for infiltration of water.
RECOMMENDATIONS

GENERAL SITE PREPARATION AND GRADING

General

The following recommendations pertain to any required grading associated with the proposed improvements and corrective grading needed to support the proposed improvements. All site preparation and grading should be performed in accordance with the City of Orange grading code requirements and the recommendations presented in this report.

Clearing and Grubbing

All significant organic material such as weeds, brush, tree branches, or roots, or construction debris such as old irrigation lines, asphalt concrete, and other decomposable material should be removed from the area to be graded. No rock or broken concrete greater than 6 inches in diameter should be utilized in the fills.

Corrective Grading

Remedial grading will serve to create a firm and workable platform for construction of the proposed developments such as new 4-story apartment buildings, new townhomes, and pavements and flatwork. The fill material encountered during our subsurface investigation will require some remedial grading in order to densify any disturbed soil and undocumented artificial fill that may be encountered during the grading operation.

It should be noted that the recommendations provided herein are based on our subsurface exploration and knowledge of the on-site geology. Actual removals may vary in configuration and volume based on observations of geologic materials and conditions encountered during grading. The bottom of all remedial grading removals should be observed by a GMU representative to verify the suitability of in-place soil prior to performing scarification and recompaction. Remedial grading recommendations are outlined below.

Subterranean Structures Building Pads: In order to create a firm and stable platform on which to construct the new subterranean structures foundations, we recommend the following:

- The subterranean structures building pads should be excavated to a depth of at least 3 feet below the bottom of the foundation.
- The bottom of the over excavation should then be scarified to a depth of at least 6 inches, moisture conditioned to 2% above optimum moisture content and recompacted to at least 90% relative compaction as determined in accordance with ASTM D1557.
Following the approval of the over-excavation bottom by a representative of GMU, the onsite material may be used as fill material to achieve the planned pad grade.

The fill material should then be placed in 6- to 8-inch-thick lifts, moisture conditioned to 2% above optimum moisture content and compacted to achieve 90% relative compaction.

Additionally, we anticipate to encounter unstable clay material at the pad elevation of the proposed subterranean parking structures. If unstable/saturated soils are encountered at the bottom of the excavation, the unstable soil may be mitigated by performing the following:

- Upon reaching the bottom of the over-exavation, the relatively soft subgrade should be kept relatively undisturbed (with very limited heavy equipment driving over it).
- A blanket of approximately 24 inches of Crushed Aggregate Base (CAB) should be placed over the relatively undisturbed bottom. The thickness of the CAB will depend on the amount of CAB to create a stable platform, however, it is not anticipated to exceed 24 inches.
- The lower foot of CAB should be placed in a 6-to-8-inch-thick lift and compacted to 90 percent relative compaction.
- The final 12 inches of CAB should also be placed in a 6-to-8-inch-thick lift and compacted to 95 percent relative compaction and the top of the 24 inches of CAB should be proof rolled under the observation of a representative of GMU.
- If the 24 inches of CAB are deemed stable by GMU, the engineered fill to reach the final pad grade may consist of onsite sandy soils, placed in 6- to 8-inch-thick lifts, moisture conditioned to optimum moisture content, and compacted to 90 percent relative compaction.
- A representative of GMU should observe the excavation bottom prior to utilizing this mitigation method.

If the subterranean buildings foundation elements are supported by Geopier or equivalent ground improvement system, then the proposed buildings slab-on-grade should be supported on 24 inches of engineered fill.

At-Grade Townhomes Foundations and Slabs: Grading recommendations for support of new townhomes foundations and slabs should consist of the following:

- The townhomes pads should be excavated to a depth of at least 2 feet below the bottom of the footing or 4 feet from existing grade, whichever is greater. The lateral extent of the overexcavation should be at least 4 feet beyond the edge of the future footings, where space is available.
- The bottom of the over-exavation should then be scarified to a depth of at least 6 inches, moisture conditioned to 2% above optimum moisture content, and recompacted to at least 90% relative compaction.
- Following the approval of the over-excavation bottom by a representative of GMU, the onsite material may be used as fill material to achieve the planned slab subgrade elevation.
The fill material should then be placed in 6- to 8-inch-thick lifts, moisture conditioned to 2% above optimum moisture content and compacted to achieve 90% relative compaction.

**Flatwork/Pavement Areas:** Grading recommendations for the support of the asphalt and concrete pavement and flatwork should consist of the following:

- The pavement/flatwork section should be over-excavated to a depth of at least 1 foot below the bottom of the pavement structural/flatwork section (i.e., 1 foot below the bottom of the aggregate base).
- The bottom of the over-excavation should then be scarified to a depth of at least 8 inches, moisture conditioned to at least 2% above optimum moisture content, and recompacted to at least 90% relative compaction.
- Following the approval of the over-excavation bottom by a representative of GMU, the onsite material may be used as fill material to achieve the planned subgrade elevation.
- The fill material should then be placed in 6- to 8-inch-thick lifts, moisture conditioned to at least 2% above optimum moisture content, and compacted to achieve 90% relative compaction.

If the existing loose fill materials are found to be disturbed to depths greater than the proposed remedial grading, then the depth of over-excavation and re-compaction should be increased accordingly in local areas as recommended by a representative of GMU.

**Temporary Excavations**

Temporary excavations for demolitions, earthwork, footings, and utility trenches are expected. We anticipate that unsurcharged excavations with vertical side slopes less than 3 feet high will generally be stable, however, some sloughing of cohesionless sandy materials encountered near the existing grade at the site should be expected. Our recommendations for temporary excavations are as follows:

- Temporary, unsurcharged excavation sides over 3 feet in height should be sloped no steeper than an inclination of 1.5H:1V (horizontal:vertical).
- Where sloped excavations are created, the tops of the slopes should be barricaded so that vehicles and storage loads do not encroach within 10 feet of the tops of the excavated slopes. A greater setback may be necessary when considering heavy vehicles, such as concrete trucks and cranes. GMU should be advised of such heavy vehicle loadings so that specific setback requirements can be established.
- If the temporary construction slopes are to be maintained during the rainy season, berms are recommended to be graded along the tops of the slopes in order to prevent runoff water from entering the excavation and eroding the slope faces.

Our temporary excavation recommendations are provided only as **minimum** guidelines. All work associated with temporary excavations should meet the minimal requirements as set forth by CAL-
OSHA. Temporary slope construction, maintenance, and safety are the responsibility of the contractor.

**Temporary Shoring**

Temporary shoring is anticipated to be placed along the perimeter of the proposed basement parking garage. Based on the assumed finished floor elevation and anticipated foundation excavations and corrective grading, shored walls may be on the order of 35 to 40 feet high.

Where shoring is required, restrained shoring will most likely be necessary to limit deflections and disruption to nearby improvements. It has been our experience that cantilever shoring might be feasible for temporary shoring to a height of only about 10 to 15 feet where allowable deflections are limited.

The temporary shoring should be designed for additional surcharges due to adjacent loads such as from construction vehicles, street traffic, and adjacent buildings. To prevent excessive surcharging of the walls, we recommend that heavy loads such as construction equipment and stockpiles of materials be kept at least 15 feet from the top of the excavations. If this is not possible, the shoring must be designed to resist the additional anticipated lateral loads. Shoring systems should be designed with sufficient rigidity to prevent detrimental lateral displacements.

For design of cantilevered shoring, a triangular distribution of lateral earth pressure may be used. It may be assumed that the drained soils, with a level surface behind the cantilevered shoring, will exert an active equivalent fluid pressure of 40 pcf.

Tied-back or braced shoring should be designed to resist a trapezoidal distribution of lateral earth pressure as recommended in Table 2 below.
Mr. Sidh Solanki, DOMINO REALTY MANAGEMENT CO.

Preliminary Geotechnical Investigation Report, Addition to Terrace Apartments, 200 City Boulevard West, Orange, California

Table 2: Temporary Shoring System Design Parameter

<table>
<thead>
<tr>
<th>Design Parameter</th>
<th>Design Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum Lateral Wall Surcharge(^1)</td>
<td>120 psf</td>
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<tr>
<td>Earth Pressure(^2)</td>
<td></td>
</tr>
<tr>
<td>From ground surface to ((2/3)H_1) (ft)</td>
<td>Increase from 0 to 39H psf</td>
</tr>
<tr>
<td>Earth Pressure(^3)</td>
<td></td>
</tr>
<tr>
<td>Between ((2/3)H_1) and ((1/3)H) (ft)</td>
<td>Uniform pressure of 39H psf</td>
</tr>
<tr>
<td>Earth Pressure(^4)</td>
<td></td>
</tr>
<tr>
<td>Below ((2/3)(H_{n+1})) (ft)</td>
<td>Reduce from 39H to 0 psf</td>
</tr>
<tr>
<td>Passive Pressure(^5)</td>
<td>350 psf to a maximum value of 3,500 psf</td>
</tr>
</tbody>
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Note:
1. For the upper 5 feet (minimum for incidental loading)
2. Where \(H_1\) is the distance from ground surface at top of wall to uppermost level of anchors.
3. Where \(H\) is the height of wall.
4. Where \(H_{n+1}\) is the distance from the base of excavation to lowermost ground anchor.
5. May assume to act over 2 times the diameter of soldier piles, neglecting the upper 1.5D \((D = \text{diameter of pile})\).

SOLDIER PILES: The frictional resistance between the soldier piles and retained earth material may be used to resist the vertical component of the anchor loads. The coefficient of friction may be taken as 0.35 based on uniform contact between the steel beam and lean mix concrete and retained soils. The portion of soldier piles below the plane of excavation may also be employed to resist the downward loads. The downward capacity may be determined using an average allowable unit skin friction of 300 psf per foot of embedment below the excavation bottom. This allowable unit skin friction incorporates a factor of safety of 2.0.

TIEBACK ANCHORS: Frictional anchors consisting of high stress thread bars are recommended. For design purposes, the active wedge adjacent to the shoring may be defined by a plane 35 degree from vertical through the bottom plane of the excavation. Anchors should extend a minimum of 20 feet beyond the assumed active wedge. Drilled friction anchors may be designed for an allowable unit skin friction of 300 psf. Pressure grouted anchors may be designed using a skin friction of 1,600 psf.

ANCHOR TESTING: All quality control and quality assurance tests should be performed based on the FHWA (1999) requirements. Two of the initial anchors should be tested to 200% of their design capacity for 24 hours. Ten anchors around the site should be tested to 200% of their capacity for a quick (½-hour) test. All anchors shall be proof tested to 150% of their design capacity.
LAGGING: Lagging should be designed for the full design pressure, but be limited to a maximum of 400 psf. GMU representative should observe the installation of lagging to insure uniform support of the excavated embankment.

GENERAL CONSTRUCTION CONSIDERATIONS: Shoring construction shall meet as a minimum, the quality control and quality assurance and construction specifications provided in FHWA (1999) guidelines. In addition, the following should be considered:

- For the movements of shoring to be reduced, the designer will have to provide for a uniform and timely mobilization of the soil pressures.
- Tiebacks or interior bracing should be loaded to the design loads prior to excavation of the adjacent soil so that load induced strains in the retaining system will not result in the system moving toward the excavation.
- A relatively stiff shoring system should be designed to limit deflections under loading. In general, we recommend designing a shoring system to deflect less than about ½-inch.
- In addition, ground subsidence and deflections can be caused by other factors, such as voids created behind the shoring system by over-excavation, soil sloughing, erosion of sand or silt layers due to perched water, etc. All voids behind the shoring system should be filled with a 1½ sac sand-cement slurry as soon as the lagging is installed to minimize potential movement or settlement.

PILE DRILLING CONSTRUCTION CONSIDERATION: The following recommendations should be considered during the drilling for the soldier piles:

- Piles drilled adjacent to one another should be drilled alternatively on different days to minimize disturbance to the open excavations.
- Drilling of the solider pile shafts can be accomplished using conventional drilling equipment.
- Caving should be anticipated within the upper approximately 35 feet, where layers of loose to medium dense sand were encountered during our field exploration.
- In the event of soil caving, it may be necessary to use casing and/or drilling mud to permit the installation of the soldier piles. The contractor should implement appropriate measures to stabilize the drilled holes.
- Drilled holes for soldier piles should not be left open overnight.
- Concrete for piles should be placed immediately after the drilling of the hole is complete.
- The concrete should be pumped to the bottom of the drilled shaft using a tremie.
- Once concrete pumping is initiated, the bottom of the tremie should remain below the surface of the concrete to prevent contamination of the concrete by soil inclusions.
- If steel casing is used, the casing should be removed as the concrete is placed.

ANCHOR INSTALLATION CONSTRUCTION CONSIDERATION: The following recommendations should be considered during the installation of the tie-back anchors:
Caving should be anticipated during the drilling of tiebacks. In the event of soil caving, it may be necessary to use casing to permit the tie-back installation. The contractor should implement appropriate measures to stabilize the drilled holes.

The anchors should be filled with concrete placed by pumping from the tip out. Pressure grouting is recommended.

**MONITORING:** In conjunction with the shoring installation, as previously discussed, a monitoring program should be set up and carried out by the contractor to determine the effects of the construction on adjacent buildings and other improvements such as streets, sidewalks, utilities and parking areas. At minimum, we recommend the following:

- Horizontal and vertical surveying of reference points on the shoring and on adjacent streets and buildings, in addition to an initial pre-construction photographic, video and/or survey of adjacent improvements.
- All supported and/or sensitive utilities should be located and monitored by the contractor.
- Reference points should be set up and read prior to the start of construction activities.
- Points should also be set on the shoring as soon as initial installations are made.
- Alternatively, inclinometers could be installed by the contractor at critical locations for a more detailed monitoring of shoring deflections.
- Surveys should be made at least once a week, and more frequently during critical construction activities, or if significant deflections are noted.

GMU can provide inclinometer materials and has the equipment and software to read and analyze the data quickly.

**STRUCTURE SEISMIC DESIGN**

No active or potentially active faults are known to cross the site, therefore, the potential for primary ground rupture due to faulting on-site is very low. However, the site will likely be subject to seismic shaking at some time in the future.

Based on our field exploration and the site soil profile, the site should be designated as Site Class D based on the measured shear wave velocities at CPT-2 and CPT-4, resulting in $V_{s30}$ of 865 feet/sec and 855 feet/sec respectively. The seismic design coefficients based on ASCE 7-10 and 2016 CBC are listed in Table 3 below.
Table 3: 2016 CBC Site Categorization and Site Coefficients

<table>
<thead>
<tr>
<th>Categorization/Coefficient</th>
<th>Design Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site Class based on Soil Profile (ASCE 7, Table 20.3-1)</td>
<td>D</td>
</tr>
<tr>
<td>Short Period Spectral Acceleration $S_s$</td>
<td>1.479</td>
</tr>
<tr>
<td>1-sec. Period Spectral Acceleration $S_1$</td>
<td>0.539</td>
</tr>
<tr>
<td>Site Coefficient $F_s$ (Table 11.4-1)</td>
<td>1.000</td>
</tr>
<tr>
<td>Site Coefficient $F_v$ (Table 11.4-2)</td>
<td>1.500</td>
</tr>
<tr>
<td>Short Period MCE Spectral Acceleration $S_{MS}$</td>
<td>1.479</td>
</tr>
<tr>
<td>1-sec. Period MCE Spectral Acceleration $S_{M1}$</td>
<td>0.809</td>
</tr>
<tr>
<td>Short Period Design Spectral Acceleration $S_{DS}$</td>
<td>0.986</td>
</tr>
<tr>
<td>1-sec. Period Design Spectral Acceleration $S_{D1}$</td>
<td>0.539</td>
</tr>
<tr>
<td>MCE Peak Ground Acceleration (PGA)</td>
<td>0.531</td>
</tr>
<tr>
<td>Site Coefficient $F_{PGA}$ (Table 11.8-1)</td>
<td>1.000</td>
</tr>
<tr>
<td>MCE Peak Ground Acceleration (PGA)</td>
<td>0.531</td>
</tr>
<tr>
<td>Mean Contributing Magnitude to MCE Event</td>
<td>6.6</td>
</tr>
</tbody>
</table>

* MCE: Maximum Considered Earthquake
** Values Obtained from USGS Earthquake Hazards Program website are based on the ASCE7-10 and 2016 CBC and site coordinates of N33.7861° and W117.8950°.

It should be recognized that much of southern California is subject to some level of damaging ground shaking as a result of movement along the major active (and potentially active) fault zones that characterize this region. Design utilizing the 2016 CBC is not meant to completely protect against damage or loss of function. Therefore, the preceding parameters should be considered as minimum design criteria.

FOUNDATION DESIGN AND CONSTRUCTION – AT-GRADE TOWNHOMES

General

The criteria contained in the following section may be used for the design and construction of the proposed townhomes. Foundation design parameters are presented below.

General Foundation Design Parameters – At-Grade Townhomes

- Bearing Material: Engineered Fill
- Removal and Re-compaction Depth: 4 feet from existing grade or a minimum of 2 feet below the bottom of foundations, whichever is deeper
- Minimum Footing Size:
  - Width: 24 inches
  - Depth: 24 inches embedment below lowest adjacent soil grade (depth)
- Allowable Bearing Capacity: 2,500 psf for the minimum footing size given above.
  - May be increased by 500 psf for each additional foot of footing depth and
by 250 for each additional foot of footing width to a maximum of 3,500 psf
- Above value may be increased by 1/3 for temporary loads such as wind or seismic

  o Settlement:
    - Static Settlement:
      - Total: 0.5 inches
      - Differential: 0.25 inches over a span of 30 feet
    - Seismic Settlement:
      - Total: 0.5 inches
      - Differential: 0.25 inches over a span of 30 feet

  o Lateral Foundation Resistance:
    - Allowable passive resistance: 240 psf/ft (disregard upper 6 inches, max 2,400 psf)
    - Allowable friction coefficient: 0.35
    - Above values may be combined without reduction and may be increased by 1/3 for temporary loads such as wind or seismic

**Slab Subsection and Slab Design**

**Minimum Thickness:** The minimum slab thickness shall be 5 inches.

**Minimum Slab Reinforcement:** Minimum slab reinforcement shall not be less than No. 4 bars placed at 18 inches on center. Welded wire mesh is not recommended. Care should be taken to position the reinforcement bars in the center of the slab.

**Slab Subgrade**

- The upper 18 inches of the on-site soils and subgrade soil should be moisture conditioned to 2 percent above the optimum moisture content, and compacted to a minimum relative compaction of 90 percent in accordance with the latest version of ASTM D1557.
- A 4-inch-thick section of compacted 3/4-inch crushed rock shall be provided directly below the slab.
- Place moisture vapor retarder per the *Moisture Vapor Transmission* section of this report.
- Sand above the moisture retarder/barrier (i.e., directly below the slab) is not a geotechnical issue. This should be provided by the structural engineer of record based on the type of slab, potential for curling, etc.
FOUNDATION DESIGN AND CONSTRUCTION – SUBTERRANEAN LEVELS

General

The criteria contained in the following section may be used for the design and construction of the proposed apartment building subterranean foundation. We have developed recommendations for two types of foundation system, which includes, 1). A conventional spread/continuous footings system or 2). Mat foundation system. The two types of foundation systems were developed based on the following:

- As discussed previously, based on the provided conceptual plans, it is our understanding that three (3) four-story apartment buildings will be supported on two-levels of subterranean parking structure.
- The bottom proposed subterranean parking structures will be situated at a depth of approximately 25 to 30 feet below the existing grade.
- Based on our field exploration, we have encountered a moist to very moist clay layer at depth of approximately 30 feet below the existing grade.
- Our shallow spread/continuous footings foundation system recommendations incorporate a 3 feet corrective grading below bottom of footings.
  - We have assumed that the maximum column load (dead plus live) is 500 kips, which yielded a total settlement of 1 inch.
  - If the maximum column load is greater than 500 kips and if there is a need for an increase in bearing capacity while limiting the associated settlement, we recommend that the proposed below-grade structures be supported by either a mat foundation system or shallow conventional spread/continuous foundation system with ground improvement such as Geopiers or equivalent systems. A ground improvement such as Geopiers or equivalent may be beneficial to eliminate the overexcavation below the foundations and reduce the shoring height. General Geopier recommendations are presented below.

General Foundation Design Parameters – Conventional Spread/Continuous Footings

Shallow spread/continuous footings foundation system recommendations provided in this section are based on corrective grading performed below the bottom of footings as discussed previously in the Corrective Grading section. The design parameters are presented below may be used for foundation structural design.

- Bearing Material: Engineered Fill
- Removal and Re-compaction Depth: 3 feet below bottom of footings
- Minimum Footing Size:
  - Width: 24 inches
  - Depth: 24 inches embedment below lowest adjacent soil grade (depth)
Allowable Bearing Capacity: 3,500 psf for the minimum footing size given above.
  ▪ May be increased by 300 psf for each additional foot of footing depth and by 150 psf for each additional foot of footing width to a maximum of 4,500 psf
  ▪ Above value may be increased by 1/3 for temporary loads such as wind or seismic

Settlement:
  ▪ Static Settlement:
    - Total: 1.0 inch
    - Differential: 0.5 inches over a span of 40 feet

Lateral Foundation Resistance:
  ▪ Allowable passive resistance: 200 psf/ft (disregard upper 6 inches, max 2,000 psf)
  ▪ Allowable friction coefficient: 0.30
  ▪ Above values may be combined without reduction and may be increased by 1/3 for temporary loads such as wind or seismic

Slab-on-Grade Subsection and Slab Design

**Minimum Thickness:** The minimum slab thickness shall be 6 inches.

**Minimum Slab Reinforcement:** Minimum slab reinforcement shall not be less than No. 4 bars placed at 18 inches on center. Welded wire mesh is not recommended. Care should be taken to position the reinforcement bars in the center of the slab.

**Slab Subgrade**
- The upper 18 inches of the on-site soils and subgrade soil should be moisture conditioned to 2 percent above the optimum moisture content, and compacted to a minimum relative compaction of 90 percent in accordance with the latest version of ASTM D1557.
- A 4-inch-thick section of compacted 3/4-inch crushed rock shall be provided directly below the slab.
- A moisture vapor retarder for below-grade parking garage should be placed per the recommendations provided in the **Moisture Vapor Transmission** section of this report.
- Sand above the moisture retarder/barrier (i.e., directly below the slab) is not a geotechnical issue. This should be provided by the structural engineer.
General Foundation Design Parameters – Mat Foundation

The following recommendations are based on corrective grading performed below the mat as discussed previously in the Corrective Grading section. The design parameters presented below may be used for foundation structural design.

- **Bearing Material**: Engineered Fill
- **Removal and Re-compaction Depth**: 3 feet below bottom of footings
- **Minimum Mat Foundation**:
  - Based on our correspondence with the project architect, it is our understanding that the structural engineer has estimated that the proposed mat will impose a pressure of 1,000 psf.
  - **Minimum thickness**: 24 inches
- **Allowable Bearing Capacity**:
  - Based on the assumptions made above, the mat foundation pressure of 1,000 psf can be also be taken as the allowable bearing capacity. However, for localized loading conditions, a maximum allowable bearing pressure of 3,500 psf may be used.
  - Above value may be increased by 1/3 for temporary loads such as wind or seismic
- **Settlement**:
  - For the purpose of preparing this preliminary settlement estimate, we have assumed a uniform bearing pressure of 1,000 psf under the mat slab.

  - **Static Settlement**:
    - Total: 1.0 inch
    - Differential: 0.5 inches over a span of 40 feet

- **Modulus of Subgrade Reaction (k)**:
  - 100 pci (static0

The mat slab should be designed by the project structural engineer.

**Geopiers or Equivalent Gravel Piers**

Based on the site conditions, it is our opinion that Geopiers or equivalent supported shallow spread/continuous foundation systems may be used for support of the proposed apartment buildings. The allowable bearing capacity provided by the Geopier system is typically up to 6,000 psf, which result in smaller size of shallow foundations based on our assumed structural loads. We recommend that once a generalized foundation plan is developed, we review the applicability of Geopier-supported foundations at this site. If suitable based on the structural loading conditions, Geopier-supported foundations could be a cost-effective solution for structure support, which should be designed by the specialty contractor.
BASEMENT WALLS

General

Basement retaining walls are anticipated for the two-level subterranean parking structure below the proposed apartment buildings.

Foundation Recommendations

It is anticipated that foundations for the basement walls will be integrated into the overall foundation design. Consequently, basement wall foundation may be sized based on recommendations from “Foundation Design Parameters”.

Lateral Earth Pressure

The following equivalent fluid pressures in pounds per cubic foot are presented with their applicable conditions:

<table>
<thead>
<tr>
<th>Type of Wall</th>
<th>Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Restrained Wall</td>
<td>60 pcf for level backfill</td>
</tr>
<tr>
<td>Unrestrained Wall</td>
<td>40 pcf for level backfill</td>
</tr>
</tbody>
</table>

The values presented above assume that the supported grade is level and that surcharge loads are not applied. In addition, these pressures are calculated assuming that a drainage system will be installed behind the basement walls and that external hydrostatic pressure will not develop behind the walls. Where adequate drainage is not provided behind the walls, further evaluation should be conducted by a geotechnical engineer and the lateral earth pressure values will need to be adjusted accordingly.

The unrestrained values are applicable only when the walls are designed and constructed as cantilevered walls allowing sufficient wall movement to mobilize “active” pressure conditions. This wall movement should not be less than .01 H (H = height of wall) for the unrestrained values to be applicable.

Dynamic Lateral Load

Given the general seismicity and the fact that the basement walls are greater than 6 feet, it is recommended that the walls also be designed for a seismic lateral load or increment. The total dynamic lateral load may be represented by an equivalent fluid pressure (EFP) of 18 pcf. The dynamic lateral load may be considered to be a triangle with the maximum pressure at the bottom.

Drainage

For basement walls that do not receive backfill and are not designed to withstand hydrostatic pressure, a drainage system behind the walls consisting of Miradrain 6000 or equivalent should be
installed. The drainage system should be connected to a collector, consist of a continuous foundation drain around the entire perimeter of the parking structure below-grade retaining wall. The drain should be placed well below the lower level floor slab-on-grade

The collector system should drain to sump pits. The sump pits should contain a sump pump that automatically pumps the water to the appropriate site drainage system. Given the size of the parking structure, it is likely that several sump pits may be necessary. The drainage system should be designed by the project Civil Engineer.

**Waterproofing**

The back side of the retaining walls should be waterproofed prior to placing subdrains or backfill. Waterproofing is outside our geotechnical purview and should be designed by a waterproofing consultant.

**STRUCTURAL CONCRETE**

Laboratory tests indicate that the onsite soils classified as having a “moderate” sulfate exposure and “S1” sulfate exposure category per ACI 318-14, Table 19.3.1.1. On this, for structural features to be in direct contact with the site soils at depth, restrictions on the type of Portland cement, water to cement ratio, and the concrete compressive strength are provided below per ACI 318-14, Table 19.3.2.1.

- Type II/V cement with a maximum water to cement ratio of 0.50, and a minimum compressive strength of 4,000 psi.

Wet curing of the concrete per ACI Publication 308 is also recommended.

The aforementioned recommendations in regards to concrete are made from a soils perspective only. Final concrete mix design is beyond our purview. All applicable codes, ordinances, regulations, and guidelines should be followed in regard to the designing a durable concrete with respect to the potential for sulfate exposure from the on-site soils and/or changes in the environment.

**FERROUS METAL CORROSION PROTECTION**

The results of the laboratory chemical tests performed on a sample of soil collected within the site indicate that the on-site soils are severely corrosive to ferrous metals. Consequently, metal structures which will be in direct contact with the soil (i.e., underground metal conduits, pipelines, metal sign posts, etc.) and/or in close proximity to the soil (wrought iron fencing, etc.) may be subject to corrosion. The use of special coatings or cathodic protection around buried metal structures has been shown to be beneficial in reducing corrosion potential. Additional provisions
will be required to address high chloride contents of the soil per the 2016 CBC to protect the concrete reinforcement. The laboratory testing program performed for this project does not address the potential for corrosion to copper piping. In this regard, a corrosion engineer should be consulted to perform more detailed testing and develop appropriate mitigation measures (if necessary).

The above discussion is provided for general guidance in regards to the corrosiveness of the on-site soils to typical metal structures used for construction. Detailed corrosion testing and recommendations for protecting buried ferrous metal and/or copper elements are beyond our purview. If detailed testing is required, a corrosion engineer should be consulted to perform the testing and develop appropriate mitigation measures.

**MOISTURE VAPOR TRANSMISSION**

**Moisture Vapor Retarder**

A vapor retarder, such as a 15-mil-thick moisture vapor retarder that meets the requirements of ASTM E1745 Class C (Stego Wrap or equivalent) should be placed directly over the prepared soil subgrade to provide protection against vapor transmission through concrete floor slabs that are anticipated to receive carpet, tile or other moisture sensitive coverings. The use of moisture vapor retarder should be determined by the project architect. At minimum, the vapor retarder should be installed as follows:

- Per the manufacture’s specifications as well as with the applicable recognized installation procedures such as ASTM E1643;
- Joints between the sheets and the openings for utility piping should be lapped and taped. If the barrier is not continuously placed across footings/ribs, the barrier should at minimum be lapped into the side of the footing/rib trenches down to the bottom of the trench; and,
- Punctures in the vapor retarder should be repaired prior to concrete placement.

It should be noted that the moisture retarder is intended only to reduce moisture vapor transmissions from the soil beneath the concrete and is consistent with the current standard of the industry in the building construction in Southern California. It is not intended to provide a “waterproof” or “vapor proof” barrier or reduce vapor transmission from sources above the retarder (i.e., concrete). The evaluation of water vapor from any source and its effect on any aspect of the proposed building space above the slab (i.e., floor covering applicability, mold growth, etc.) is beyond our purview and the scope of this report.
SURFACE DRAINAGE

Surface drainage should be carefully controlled during and after grading to prevent ponding and uncontrolled runoff adjacent to the structures. Particular care will be required during grading to maintain slopes, swales, and other erosion control measures needed to direct runoff toward permanent surface drainage facilities. Positive drainage of at least 2% away from the perimeters of the structures and site pavements should be incorporated into the design. In addition, it is recommended that nuisance water be directed away from the perimeter of the structures by the use of area drains in adjacent landscape and flatwork areas and roof drains tied into the site storm drain system.

UTILITY TRENCH BACKFILL CONSIDERATIONS

General

New utility line pipeline trenches should be backfilled with select bedding materials beneath and around the pipes (pipe zone) and compacted soil above the pipe bedding. Recommendations for the types of the materials to be used and the proper placement of these materials are provided in the following sections.

Pipe Zone (Bedding and Shading)

The pipe bedding and shading materials should extend from at least 6 inches below the pipes to at least 12 inches above the crown of the pipes. Pipe bedding and shading should consist of either clean sand with a sand equivalent (SE) of at least 30, or crushed rock. If crushed rock is used, it should consist of ¾-inch crushed rock that conforms to Table 200-1.2.1 (A) of the 2015 “Greenbook.” Pipe bedding and shading should also meet the minimum requirements of the City of Orange. If the requirements of the County or City are more stringent, they should take precedence over the geotechnical recommendations. Sufficient laboratory testing should be performed to verify the bedding and shading meets the minimum requirements of the Greenbook and City of Orange grading codes.

Based on our subsurface exploration and knowledge of the onsite materials, the soils that will be excavated from the pipeline trenches will not meet the recommendations for pipe bedding and shading materials; therefore, imported materials will be required for pipe bedding and shading.

Granular pipe bedding and shading material should be properly placed in thicknesses not exceeding 3 feet, and then sufficiently flooded or jetted in place. Crushed rock, if used, should be wrapped with filter fabric (Mirafi 160N, or equivalent; Mirafi 140N filter fabric is suitable if available) to prevent the migration of fines into the rock.
Trench Backfill

All existing soil material within the limits of the site are considered suitable for use as trench backfill above the pipe bedding and shading zone if care is taken to remove all significant organic and other decomposable debris, moisture condition the soil materials as necessary, and separate and selectively place and/or stockpile any inert materials larger than 6 inches in maximum diameter.

Imported soils are not anticipated for backfill since the on-site soils are suitable. However, if imported soils are used, the soils should consist of clean, granular materials with physical and chemical characteristics similar to or better than those described herein for on-site soils. Any imported soils to be used as backfill should be evaluated and approved by GMU prior to placement.

Soils to be used as trench backfill should be moistened, dried, or blended as necessary to achieve a minimum of 2% over optimum moisture content (i.e., if the optimum moisture content is 14%, the compacted fill’s moisture content shall be at least 16%), placed in lifts which, prior to compaction, shall not exceed the thickness specified in section 306-12.3 of the 2015 “Greenbook” for various types of equipment, and mechanically compacted/densified to at least 90% relative compaction as determined by ASTM Test Method D 1557. Jetting is not permitted in this trench zone.

No rock or broken concrete greater than 6 inches in maximum diameter should be utilized in the trench backfills.

ASPHALT CONCRETE PAVEMENT THICKNESS RECOMMENDATIONS

Based on the R-value test results, as well as testing completed in the vicinity, an R-value of 50 was used for the design. Table 4 below provides recommended minimum thicknesses for asphalt concrete (AC) and aggregate base sections for two traffic indices.

<table>
<thead>
<tr>
<th>Location</th>
<th>R-Value</th>
<th>Traffic Index</th>
<th>Asphalt Concrete (in.)</th>
<th>Aggregate Base* (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Driveways</td>
<td>50</td>
<td>5.5</td>
<td>4.0</td>
<td>4.0</td>
</tr>
<tr>
<td>Parking Stalls</td>
<td>50</td>
<td>4.0</td>
<td>3.0</td>
<td>4.0</td>
</tr>
</tbody>
</table>

* assumed R-Value = 78

Asphalt concrete pavement construction should be in accordance with the following recommendations:
The planned pavement structural sections should consist of aggregate base materials (AB) and asphalt concrete materials (AC) of a type meeting the minimum Caltrans and City of Orange requirements.

- The subgrade soils should be prepared in accordance with the Site Corrective Grading section of this report.
- The AB and AC should be compacted to at least 95% relative compaction.

**CONCRETE PAVEMENT THICKNESS RECOMMENDATIONS**

It is anticipated that Portland Cement Concrete (PCC) pavement will be constructed as part of the drive way approaches. Table 5 below provides minimum PCC pavement section constructed over properly prepared subgrade and AB section.

<table>
<thead>
<tr>
<th>Location</th>
<th>R-Value</th>
<th>Traffic Index</th>
<th>PCC (in.)</th>
<th>Aggregate Base* (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Driveways</td>
<td>50</td>
<td>6.0</td>
<td>6.0</td>
<td>4.0</td>
</tr>
</tbody>
</table>

* assumed R-Value = 78

Concrete pavement construction should be in accordance with the following recommendations:

- The pavement structural sections should consist of aggregate base materials (AB) and Portland Cement Concrete (PCC).
- The subgrade soils should be prepared in accordance with the Site Corrective Grading section of this report.
- The AB should be compacted to at least 95% relative compaction.

**SITE INFILTRATION**

Based on our preliminary percolation test result as discussed previously in this report and as presented in Appendix D, all four test locations showed adequate infiltration rates within the upper 5 to 10 feet of the site soils to design for an infiltration BMP. Additional field infiltration testing should be performed at the actual planned BMP location for confirmation once the BMP type, location and depth are selected. At minimum, the proposed infiltration BMP must comply with the setback requirements shown on Table 6 below.
Table 6: BMP Setback Requirements

<table>
<thead>
<tr>
<th>Property lines and public right of way</th>
<th>• A minimum of 5 feet setback.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Any foundation</td>
<td>• A minimum of 15 feet setback or within 1:1 plane drawn up from the bottom of foundation, whichever is greater.</td>
</tr>
<tr>
<td>Water wells used for drinking water</td>
<td>• A minimum of 100 feet setback.</td>
</tr>
</tbody>
</table>

CONCRETE FLATWORK DESIGN

We recommend that the subgrade for the subject concrete flatwork be moisture conditioned to 2% over optimum to a depth of 18 inches below finish grade and compacted to 90% relative compaction. A 2-inch-thick section of Class 2 aggregate base (AB) or crushed miscellaneous base (CMB) should then be placed on the compacted subgrade soils, brought to 2% above optimum moisture condition, and compacted to 95% relative compaction prior to placement of walkway and patio flatwork reinforcing steel and concrete. For flatwork concrete underlain by aggregate base, Type II/V cement with a maximum water/cement ratio of 0.50 and minimum compressive strength of 3,250 psi may be used. Table 7 below summarizes our flatwork recommendations:

Table 7: Concrete Flatwork Recommendations

<table>
<thead>
<tr>
<th>Description</th>
<th>Subgrade Preparation (1)</th>
<th>Aggregate Base (Class 2 or CMB) (2)</th>
<th>Minimum Concrete Thickness</th>
<th>Reinforcement(3)</th>
<th>Control Joint Spacing (Maximum)</th>
<th>Concrete(5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete Paving (Patio, and flatwork/stair adjacent)</td>
<td>2% over optimum to 18 inches at 90% relative compaction</td>
<td>2-inch-thick section at 95% relative compaction</td>
<td>5 inches</td>
<td>No. 3 bars @ 18”o.c.b.w. and dowel into building and curb using 9-inch Speed Dowels @ 18”o.c</td>
<td>10-foot x 10-foot using 9-inch speed dowels with No. 3 bars @ 18” o.c.</td>
<td>Type II/V 3,250 psi min.</td>
</tr>
</tbody>
</table>

(1) The moisture content and compaction of the subgrade must be verified by the geotechnical consultant prior to base placement.
(2) For pedestrian usages only, S.E. 30 sand may be used instead of Aggregate Base.
(3) Reinforcement to be placed in the middle of the recommended concrete section.
(4) Control Joints: Suggested spacing of Pedestrian areas at 10’.
(5) Final concrete mix design to be supplied by others.
Mr. Sidh Solanki, DOMINO REALTY MANAGEMENT CO.

Preliminary Geotechnical Investigation Report, Addition to Terrace Apartments, 200 City Boulevard West, Orange, California

PLAN REVIEW / GEOTECHNICAL TESTING DURING GRADING / FUTURE REPORT

Plan Review

GMU should review the final construction plans to confirm that they are consistent with our recommendations provided in this report.

Geotechnical Testing

Geotechnical observation and testing should be performed by GMU during the following stages of precise grading and construction:

- During site clearing and grubbing.
- During removal of any buried irrigation lines or other subsurface structures.
- During all phases of grading including over-excavation, temporary excavations, removals, scarification, ground preparation, moisture conditioning, proof-rolling, and placement and compaction of all fill materials.
- During the installation of temporary shoring.
- During grading for the proposed townhomes.
- During grading for the proposed apartment buildings.
- During pavement and flatwork section placement and compaction.
- Foundation slab construction.
- When any unusual conditions are encountered.

Future Report

If required, a report summarizing our construction observation/testing services will be prepared at project completion.
LIMITATIONS

All parties reviewing or utilizing this report should recognize that the findings, conclusions, and recommendations presented represent the results of our professional geological and geotechnical engineering efforts and judgements. Due to the inexact nature of the state of the art of these professions and the possible occurrence of undetected variables in subsurface conditions, we cannot guarantee that the conditions actually encountered during grading and foundation installation will be identical to those observed and sampled during our study or that there are no unknown subsurface conditions which could have an adverse effect on the use of the property. We have exercised a degree of care comparable to the standard of practice presently maintained by other professionals in the fields of geotechnical engineering and engineering geology, and believe that our findings present a reasonably representative description of geotechnical conditions and their probable influence on the grading and use of the property.

Because our conclusions and recommendations are based on a limited amount of current and previous geotechnical exploration and analysis, all parties should recognize the need for possible revisions to our conclusions and recommendations during grading of the project. Additionally, our conclusions and recommendations are based on the assumption that our firm will act as the geotechnical engineer of record during grading of the project to observe the actual conditions exposed, to verify our design concepts and the grading contractor's general compliance with the project geotechnical specifications, and to provide revised conclusions and recommendations should subsurface conditions differ significantly from those used as the basis for our conclusions and recommendations presented in this report.

Detailed corrosion testing and recommendations for protecting buried ferrous metal and/or copper elements are beyond our purview.

This report has not been prepared for use by other parties or projects other than those named or described herein. This report may not contain sufficient information for other parties or other purposes.
Mr. Sidh Solanki, DOMINO REALTY MANAGEMENT CO.
Preliminary Geotechnical Investigation Report, Addition to Terrace Apartments, 200 City Boulevard West, Orange, California

CLOSURE

We are pleased to present the results of our geotechnical foundation investigation for this project. The Plates and Appendices that complete this report are listed in the Table of Contents.

If you have any questions concerning our findings or recommendations, please do not hesitate to contact us and we will be happy to discuss them with you.

Respectfully submitted,

GMU GEOTECHNICAL, INC.

Nadim Sunna, MS, PE 84197
Project Geotechnical Engineer

Kathryn Farrington, PG, CEG 2611
Project Geologist

Reviewed By:

S. Ali Bastani, Ph.D., PE, GE 2458
Director of Engineering

ns/17-176-00 (11-17-17)
REFERENCES

SITE-SPECIFIC REFERENCES


TECHNICAL REFERENCES


California Department of Conservation, Division of Mines and Geology, 2001, Seismic Hazard Zone Report for the Anaheim and Newport Beach 7.5-Minute Quadrangle, Orange County, California: Seismic Hazard Zone Report 003, 47 pp. plus 3 plates.


California Geological Survey (CGS), 2006, Preliminary Digital Geologic Map of the Santa Ana 30’x60’ Quadrangle, Southern California.


APPENDIX A

Geotechnical Exploration Procedures, Drill Hole Logs, and Cone Penetration Testing Data by GMU Geotechnical, Inc.
APPENDIX A

GMU GEOTECHNICAL EXPLORATION PROCEDURES, DRILL HOLE Logs, AND CONE PENETRATION TESTING DATA

Our exploration at the subject site consisted of eleven (11) drilled holes to a maximum depth of 71.5 feet below the existing grade and seven (7) Cone Penetration Testing (CPT) soundings to a maximum depth of 75 feet below the existing grade. Our drilled holes were logged by a Staff Engineer, and drive, bulk, and Standard Penetration Test (SPT) samples of the excavated soils were collected. Blow counts recorded during sampling from the California Modified Sampler (Cal Mod) and SPT are shown on the drill hole logs. The logs of each drill hole are contained in this Appendix A, and the Legend to Logs is presented as Plates A-1 and A-2. The CPT data are presented in Appendix A-1. The approximate locations of the drill holes and CPT’s are shown on Plate 2 – Geotechnical Map.

“Undisturbed” Cal Mod samples were taken using a 3.0-inch, thin walled, outside-diameter drive sampler which contains a 2.416-inch-diameter brass sample sleeve that is 6 inches in length. SPT samples were obtained using a 2.0-inch outside diameter split spoon sampler without liners. Bulk samples of the soil materials were also collected from the upper 5 feet of the site soils.

The geologic and engineering field descriptions and classifications that appear on these logs are prepared according to Corps of Engineers and Bureau of Reclamation standards. Major soil classifications are prepared according to the Unified Soil Classification System as modified by ASTM Standard No. 2487. Since the descriptions and classifications that appear on the Log of Drill Hole are intended to be that which most accurately describe a given interval of a drill hole (frequently an interval of several feet), discrepancies do occur in the Unified Soil Classification System nomenclature between that interval and a particular sample in that interval. For example, an 8-foot-thick interval in a log may be identified as silty sand (SM) while one sample taken within the interval may have individually been identified as sandy silt (ML). This discrepancy is frequently allowed to remain to emphasize the occurrence of local textural variations in the interval.
### MAJOR DIVISIONS

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Group Letter</th>
<th>TYPICAL NAMES</th>
</tr>
</thead>
<tbody>
<tr>
<td>GW</td>
<td>Clean Gravels</td>
<td>Well Graded Gravels and Gravel-Sand Mixtures, Little or No Fines.</td>
</tr>
<tr>
<td>GM</td>
<td>Gravels With Fines</td>
<td>Silty Gravels, Gravel-Sand-Silt Mixtures.</td>
</tr>
<tr>
<td>GC</td>
<td>Clayey Gravels, Gravel-Sand-Clay Mixtures.</td>
<td></td>
</tr>
<tr>
<td>SW</td>
<td>Clean Sands</td>
<td>Well Graded Sands and Gravelly Sands, Little or No Fines.</td>
</tr>
<tr>
<td>SP</td>
<td>Poorly Graded Sands and Gravelly Sands, Little or No Fines.</td>
<td></td>
</tr>
<tr>
<td>SM</td>
<td>Silty Sands, Sand-Silt Mixtures.</td>
<td></td>
</tr>
<tr>
<td>SC</td>
<td>Clayey Sands, Sand-Clay Mixtures.</td>
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</table>

### FINE-GRAINED SOILS

<table>
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<tr>
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<th>Group Letter</th>
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<tbody>
<tr>
<td>ML</td>
<td>Inorganic Silts, Very Fine Sands, Rock Flour, Silty or Clayey Fine Sands or Clayey Silts With Slight Plasticity.</td>
<td></td>
</tr>
<tr>
<td>CL</td>
<td>Inorganic Silts, Gravelly Clays, Sandy Clays, Silty Clays, Lean Clays.</td>
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</tr>
<tr>
<td>OL</td>
<td>Organic Silts and Organic Silty Clays of Low Plasticity</td>
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</tr>
<tr>
<td>MH</td>
<td>Inorganic Silts, Micaeous or Diatomaceous Fine Sandy or Silty Soils, Elastic Silts.</td>
<td></td>
</tr>
<tr>
<td>CH</td>
<td>Inorganic Clays of High Plasticity, Fat Clays.</td>
<td></td>
</tr>
<tr>
<td>OH</td>
<td>Organic Clays of Medium To High Plasticity, Organic Silts.</td>
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</tr>
</tbody>
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### HIGHLY ORGANIC SOILS

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<tbody>
<tr>
<td>PT</td>
<td>Peat and Other Highly Organic Soils.</td>
</tr>
</tbody>
</table>

The descriptive terminology of the logs is modified from current ASTM Standards to suit the purposes of this study.

### ADDITIONAL TESTS

- DS = Direct Shear
- HY = Hydrometer Test
- TC = Triaxial Compression Test
- UC = Unconfined Compression
- CN = Consolidation Test
- T = Time Rate
- EX = Expansion Test
- CP = Compaction Test
- PS = Particle Size Distribution
- EI = Expansion Index
- SE = Sand Equivalent Test
- AL = Atterberg Limits
- FC = Chemical Tests
- RV = Resistance Value
- SG = Specific Gravity
- SU = Sulphates
- CH = Chlorides
- MR = Minimum Resistivity
- pH = Natural Undisturbed Sample
- N = Remolded Sample
- R = Remolded Sample
- CS = Collapse Test/Swell-Settlement

### GEOLOGIC NOMENCLATURE

- B = Bedding
- C = Contact
- J = Joint
- F = Fracture
- Fl = Fault
- RS = Rupture Surface
- S = Shear
- F = Fracture
- Fl = Fault
- S = Shear
- = Groundwater

### SAMPLE SYMBOLS

- Undisturbed Sample (California Sample)
- Bulk Sample
- Unsuccessful Sampling Attempt
- SPT Sample

10: 10 Blows for 12-Inches Penetration
6/4: 6 Blows Per 4-Inches Penetration
P: Push
13: Uncorrected Blow Counts ("N" Values) for 12-Inches Penetration - Standard Penetration Test (SPT)

### LEGEND TO LOGS

ASTM Designation: D 2487
(Based on Unified Soil Classification System)
### SOIL DENSITY/CONSISTENCY

#### FINE GRAINED

<table>
<thead>
<tr>
<th>Consistency</th>
<th>Field Test</th>
<th>SPT (#blows/foot)</th>
<th>Mod (#blows/foot)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Soft</td>
<td>Easily penetrated by thumb, exudes between fingers</td>
<td>2-4</td>
<td>3-6</td>
</tr>
<tr>
<td>Soft</td>
<td>Easily penetrated one inch by thumb, molded by fingers</td>
<td>4-8</td>
<td>6-12</td>
</tr>
<tr>
<td>Firm</td>
<td>Penetrated over 1/2 inch by thumb with moderate effort</td>
<td>8-15</td>
<td>12-25</td>
</tr>
<tr>
<td>Stiff</td>
<td>Penetrated about 1/2 inch by thumb with great effort</td>
<td>15-30</td>
<td>25-50</td>
</tr>
<tr>
<td>Very Stiff</td>
<td>Readily indented by thumbnail</td>
<td>&gt;30</td>
<td>&gt;50</td>
</tr>
<tr>
<td>Hard</td>
<td>Indented with difficulty by thumbnail</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### COARSE GRAINED

<table>
<thead>
<tr>
<th>Density</th>
<th>Field Test</th>
<th>SPT (#blows/foot)</th>
<th>Mod (#blows/foot)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Loose</td>
<td>Easily penetrated with 0.5&quot; rod pushed by hand</td>
<td>10-30</td>
<td>12-35</td>
</tr>
<tr>
<td>Loose</td>
<td>Easily penetrated with 0.5&quot; rod pushed by hand</td>
<td>15-30</td>
<td>25-50</td>
</tr>
<tr>
<td>Medium Dense</td>
<td>Easily penetrated 1&quot; with 0.5&quot; rod driven by 5lb hammer</td>
<td>31-50</td>
<td>35-60</td>
</tr>
<tr>
<td>Dense</td>
<td>Difficult to penetrate 1&quot; with 0.5&quot; rod driven by 5lb hammer</td>
<td>&gt;50</td>
<td>&gt;60</td>
</tr>
<tr>
<td>Very Dense</td>
<td>Penetrated few inches with 0.5&quot; rod driven by 5lb hammer</td>
<td></td>
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### BEDROCK HARDNESS

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<th>Density</th>
<th>Field Test</th>
<th>SPT (#blows/foot)</th>
</tr>
</thead>
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<tr>
<td>Soft</td>
<td>Can be crushed by hand, soil like and structureless</td>
<td>1-30</td>
</tr>
<tr>
<td>Moderately Hard</td>
<td>Can be grooved with fingernails, crumbles with hammer</td>
<td>30-50</td>
</tr>
<tr>
<td>Hard</td>
<td>Can't break by hand, can be grooved with knife</td>
<td>50-100</td>
</tr>
<tr>
<td>Very Hard</td>
<td>Scratches with knife, chips with hammer blows</td>
<td>&gt;100</td>
</tr>
</tbody>
</table>

### GRAIN SIZE

<table>
<thead>
<tr>
<th>Description</th>
<th>Sieve Size</th>
<th>Grain Size</th>
<th>Approximate Size</th>
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</thead>
<tbody>
<tr>
<td>Boulders</td>
<td>&gt;12&quot;</td>
<td>&gt;12&quot;</td>
<td>Larger than a basketball</td>
</tr>
<tr>
<td>Cobble</td>
<td>3-12&quot;</td>
<td>3-12&quot;</td>
<td>Fist-sized to basketball-sized</td>
</tr>
<tr>
<td>Gravel</td>
<td>Coarse 3/4-3&quot;</td>
<td>3/4-3&quot;</td>
<td>Thumb-sized to fist-sized</td>
</tr>
<tr>
<td>Fine #4-3/4&quot;</td>
<td>0.19-0.75&quot;</td>
<td>Pea-sized to thumb-sized</td>
<td></td>
</tr>
<tr>
<td>Sand</td>
<td>Coarse #10-#4</td>
<td>0.079-0.19&quot;</td>
<td>Rock-salt-sized to pea-sized</td>
</tr>
<tr>
<td>Medium #40-#10</td>
<td>0.017-0.079&quot;</td>
<td>Sugar-sized to rock salt-sized</td>
<td></td>
</tr>
<tr>
<td>Fine #200-#40</td>
<td>0.0029-0.017&quot;</td>
<td>Flour-sized to sugar-sized</td>
<td></td>
</tr>
<tr>
<td>Fines</td>
<td>Passing #200</td>
<td>&lt;0.0029&quot;</td>
<td>Flour-sized and smaller</td>
</tr>
</tbody>
</table>

### MOISTURE CONTENT

- **Dry:** Very little or no moisture
- **Damp:** Some moisture but less than optimum
- **Moist:** Near optimum
- **Very Moist:** Above optimum
- **Wet/Saturated:** Contains free moisture

### MODIFIERS

- **Trace:** 1%
- **Few:** 1-5%
- **Some:** 5-12%
- **Numerous:** 12-20%
- **Abundant:** >20%

---

**LEGEND TO LOGS**

**Plate A-2**

**GMU Geotechnical, Inc.**

**Date:** 8/11/16/2012
<table>
<thead>
<tr>
<th>ELEVATION, feet</th>
<th>DEPTH, feet</th>
<th>GEOLOGICAL CLASSIFICATION AND DESCRIPTION</th>
<th>ORIENTATION DATA</th>
<th>ENGINEERING CLASSIFICATION AND DESCRIPTION</th>
<th>SAMPLE DATA</th>
<th>TEST DATA</th>
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<tbody>
<tr>
<td>130</td>
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<td>ALLUVIAL FAN DEPOSITS (Qyf)</td>
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<tr>
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<td>120</td>
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<tr>
<td>125</td>
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<td>P O O R L Y G R A D E D  S A N D  (S P) ,</td>
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<td></td>
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<tr>
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<td>white, light brown to light gray-brown,</td>
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<tr>
<td></td>
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<td>dry, loose, fine- to- coarse-grained sand</td>
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<td>120</td>
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<tr>
<td>125</td>
<td></td>
<td>S I L T Y  S A N D  ( S M ) ;  light brown,</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>dry, medium dense, fine-grained sand</td>
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</tr>
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<tr>
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<td>P O O R L Y G R A D E D  S A N D  (S P) ,</td>
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<tr>
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<td>light tan brown, damp, medium dense to</td>
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<td>dense, fine- to- coarse-grained sand</td>
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</tr>
<tr>
<td>ELEVATION, ft</td>
<td>DEPTH, ft</td>
<td>GRAPHIC LOG</td>
<td>GEOLOGICAL CLASSIFICATION AND DESCRIPTION</td>
<td>ORIENTATION DATA</td>
<td>ENGINEERING CLASSIFICATION AND DESCRIPTION</td>
<td>SAMPLE DATA</td>
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<tr>
<td>---------------</td>
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<td>---------------------------------------------</td>
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<tr>
<td></td>
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<td>medium dense, no recovery</td>
<td></td>
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<td></td>
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<td>SANDY SILTY CLAY (CL-ML)</td>
<td></td>
<td></td>
<td>9</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>gray-brown, very moist, firm, fine-grained sand</td>
<td></td>
<td></td>
<td>11</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>becomes gray and dry</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
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<td>SILTY CLAY (CL); gray-brown, moist, stiff</td>
<td></td>
<td></td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>5</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>SILTY SAND (SM); brown, dry to slightly moist, medium dense, fine-grained sand</td>
<td></td>
<td></td>
<td>5</td>
</tr>
</tbody>
</table>

**Log of Drill Hole DH-1**

Project: Terrace Apartments Expansion  
Project Location: 200 City Boulevard West  
Project Number: 17-176-00
**GEOLOGICAL CLASSIFICATION AND DESCRIPTION**

- 85 ft: **SANDY SILT (ML)**; light gray-brown, very moist, very stiff
- 80 ft: **SANDY CLAY (CL)**; brown, very moist, stiff to very stiff
- 75 ft: *Firm to stiff*
- 70 ft: **POORLY GRADED SAND WITH SILT (SP-SM)**; light gray-brown, dry to damp, dense, fine- to coarse-grained sand
- 65 ft: **SANDY SILT (ML)**; brown, very moist, stiff, fine-grained sand.
Total Depth = 71.5 feet
Groundwater not encountered
### Geological Classification and Description

- **ALLUVIAL FAN DEPOSITS (Qvf)**
- **Asphalt Concrete (approximately 4 inches)**
- **SILTY SAND (SM); light gray-brown, damp, loose to medium dense, fine- to coarse-grained sand**
- **POORLY GRADED SAND (SP); light brown, moist, medium dense, fine- to coarse-grained sand**
- **POORLY GRADED SAND WITH SILT (SP-SM); light brown, slightly moist, fine- to medium coarse-grained sand, loose to medium dense**

### Additional Tests

<table>
<thead>
<tr>
<th>Elevation, feet</th>
<th>Asphalt Concrete (approximately 4 inches)</th>
<th>Driving Method and Drop</th>
<th>Auto Hammer</th>
</tr>
</thead>
<tbody>
<tr>
<td>130</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>125</td>
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<tr>
<td>105</td>
<td></td>
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</tr>
</tbody>
</table>

### Graphical Log

- **ELEVATION, feet**
- **DEPTH, feet**
- **ORIENTATION DATA**
- **ENGINEERING CLASSIFICATION AND DESCRIPTION**

### Chemical Tests

<table>
<thead>
<tr>
<th>Depth, ft</th>
<th>No. of Blows</th>
<th>Driving Weight, lb</th>
<th>Moisture, %</th>
<th>Dry Density, pcf</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>10</td>
<td>4</td>
<td>103</td>
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<tr>
<td>15</td>
<td>15</td>
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### Project Details

- **Project Location:** 200 City Boulevard West
- **Project Number:** 17-176-00
- **Drill Hole DH-2**

---

**GMU Geotechnical Inc.**

**Drill Hole DH-2**
<table>
<thead>
<tr>
<th>ELEVATION, feet</th>
<th>DEPTH, feet</th>
<th>GRAPHIC LOG</th>
<th>GEOLOGICAL CLASSIFICATION AND DESCRIPTION</th>
<th>ORIENTATION DATA</th>
<th>ENGINEERING CLASSIFICATION AND DESCRIPTION</th>
<th>SAMPLE DATA</th>
<th>TEST DATA</th>
</tr>
</thead>
<tbody>
<tr>
<td>110</td>
<td></td>
<td></td>
<td>zone of CLAYEY SILT (ML); light grayish brown, very moist, very stiff</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>25</td>
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<td></td>
<td>SILTY SAND (SM); light grayish brown, very moist, medium dense, fine-grained sand</td>
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</table>

DRILL HOLE DH- 2

PROJECT LOCATION: 200 City Boulevard West
PROJECT NUMBER: 17-176-00

PROJECT: Terrace Apartments Expansion Log of Drill Hole DH- 2

DH_REV3 17-176-00.GPJ  GMULAB.GPJ  11/20/17
## Geotechnical Classification and Description

**ALLUVIAL FAN DEPOSITS (Quf)**
- **Silty Sand (SM)**; brown, moist to very moist, medium dense, medium coarse-grained sand

**Poorly Graded Sand (SP)**; light gray-brown, dry, dense, fine-to-coarse-grained sand

**Poorly Graded Sand with Silt (SP-SM)**; light brown, moist, medium dense, fine-to-coarse-grained sand
<table>
<thead>
<tr>
<th>ELEVATION, ft</th>
<th>DEPTH, ft</th>
<th>GRAPHIC LOG</th>
<th>GEOLOGICAL CLASSIFICATION AND DESCRIPTION</th>
<th>ORIENTATION DATA</th>
<th>ENGINEERING CLASSIFICATION AND DESCRIPTION</th>
<th>SAMPLE DATA</th>
<th>TEST DATA</th>
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<tbody>
<tr>
<td></td>
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<td></td>
<td>becomes loose</td>
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<td>POORELY GRADED SAND (SP); light gray-brown, moist, medium dense, fine-to-coarse-grained sand</td>
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<td>SILEY SAND (SM); light brown, moist, medium dense, fine-grained sand</td>
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<td>SANDY CLAY (CL); brown, very moist, firm, fine-grained sand</td>
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<td>4</td>
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</tr>
<tr>
<td>ELEVATION, feet</td>
<td>DEPTH, feet</td>
<td>GRAPHIC LOG</td>
<td>GEOLOGICAL CLASSIFICATION AND DESCRIPTION</td>
<td>ORIENTATION DATA</td>
<td>ENGINEERING CLASSIFICATION AND DESCRIPTION</td>
<td>SAMPLE DATA</td>
<td>TEST DATA</td>
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<td></td>
<td></td>
<td></td>
<td>SILTY SAND (SM); light gray-brown, damp to moist, medium dense, fine-grained sand</td>
<td></td>
<td>5</td>
<td>12</td>
<td>98</td>
</tr>
<tr>
<td></td>
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<td></td>
<td>SAND SILT (ML); brown, moist, firm, fine-grained sand</td>
<td></td>
<td>3</td>
<td>3</td>
<td>5</td>
</tr>
</tbody>
</table>

**Log of Drill Hole DH- 3**

**Project Location:** 200 City Boulevard West

**Project Number:** 17-176-00
**Log of Drill Hole DH- 4**

**Sheet 1 of 4**

<table>
<thead>
<tr>
<th>Date(s) Drilled</th>
<th>Logged By</th>
<th>MTF</th>
<th>Checked By</th>
<th>NS</th>
</tr>
</thead>
<tbody>
<tr>
<td>9/29/2017</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Drilling Method**
- Hollow Stem Auger
- Drilling Contractor: Gregg Drilling

**Total Depth of Drill Hole** 71.5 feet

**Approx. Surface Elevation, ft MSL** 131.0

**Groundwater Depth [Elevation], feet** Not Encountered [0.0]

**Sampling Method(s)** California Modified, SPT, & Bulk

**Backfill** Native

**Remarks**
- Driving Method and Drop: Auto Hammer

### Geological Classification and Description

<table>
<thead>
<tr>
<th>Elevation, feet</th>
<th>Orientation Data</th>
<th>Geological Classification and Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>130</td>
<td></td>
<td>ARTIFICIAL FILL (Qaf)</td>
</tr>
<tr>
<td>125</td>
<td></td>
<td>Asphalt Concrete (approximately 4 inches)</td>
</tr>
<tr>
<td>120</td>
<td></td>
<td>SILTY SAND (SM); light brown, damp, loose, fine to medium grained sand</td>
</tr>
<tr>
<td>115</td>
<td></td>
<td>ALLUVIAL FAN DEPOSITS (Qvf)</td>
</tr>
<tr>
<td>110</td>
<td></td>
<td>SANDY Silt (ML); light brown, moist to very moist, firm, fine grained sand</td>
</tr>
<tr>
<td>100</td>
<td></td>
<td>SILTY SAND (SM); light brown, damp, loose, fine to medium grained sand</td>
</tr>
<tr>
<td>95</td>
<td></td>
<td>SANDY Silt (ML); tight brown, moist to very moist, firm, fine grained sand</td>
</tr>
<tr>
<td>90</td>
<td></td>
<td>SILTY SAND (SM); brown to light brown, very moist, loose to medium dense, fine to medium grained sand</td>
</tr>
<tr>
<td>85</td>
<td></td>
<td>SANDY Silt (ML); tight brown, very moist, stiff</td>
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<tr>
<td>80</td>
<td></td>
<td>POORLY GRADED SAND WITH SILT (SP-SM); light gray-brown, dry, medium dense, fine to coarse-grained sand, with trace fine gravel</td>
</tr>
</tbody>
</table>

**Sample Data**

<table>
<thead>
<tr>
<th>SAMPLE</th>
<th>NUMBER OF BLOWS / 6&quot;</th>
<th>DRIVING WEIGHT, lbs</th>
<th>MOISTURE CONTENT, %</th>
<th>DRY UNIT WEIGHT, pcf</th>
<th>ADDITIONAL TESTS</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>130</td>
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<td>17</td>
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<td>103</td>
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<td></td>
</tr>
</tbody>
</table>

**Project Location:** 200 City Boulevard West

**Project Number:** 17-176-00

**Drill Hole Number:** DH-4

**Remarks:**
- Sampling Method(s): Drilling
- Drilling Contractor: Gregg Drilling
- Drilling Rig Type: M12
- Diameter of Hole, inches: 8"
- Total Depth of Drill Hole: 71.5 feet
- Approx. Surface Elevation, ft MSL: 131.0
- Groundwater Depth [Elevation], feet: Not Encountered [0.0]
- Sampling Method(s): California Modified, SPT, & Bulk
- Backfill: Native
- Driving Method and Drop: Auto Hammer

**Drill Rig:** Marlo M12

**Remarks:**
- Artificial Fill (Qaf)
- Alluvial Fan Deposits (Qvf)
### Log of Drill Hole DH- 4

#### Project: Terrace Apartments Expansion
- **Project Location:** 200 City Boulevard West
- **Project Number:** 17-176-00

#### Log Sheet 2 of 4

<table>
<thead>
<tr>
<th>ELEVATION, ft</th>
<th>DEPTH, ft</th>
<th>GRAPHIC LOG</th>
<th>GEOLOGICAL CLASSIFICATION AND DESCRIPTION</th>
<th>ORIENTATION DATA</th>
<th>ENGINEERING CLASSIFICATION AND DESCRIPTION</th>
<th>SAMPLE DATA</th>
<th>TEST DATA</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>SILTY SAND</strong> (SM): light brown, damp,</td>
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<td></td>
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<td>loose, fine-grained sand, trace clay</td>
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<td></td>
<td><strong>SANDY CLAY</strong> (CL): light grayish brown,</td>
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<td>very moist, stiff, fine-grained sand</td>
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<td><strong>SANDY SILT</strong> (ML): light gray and white,</td>
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<td></td>
<td>damp to moist, very stiff, fine grained</td>
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</tbody>
</table>

**Additional Tests**

- **Dry Unit Weight,pcf:**
  - ELEVATION, feet
  - DEPTH, ft
  - GRAPHIC LOG
  - GEOLOGICAL CLASSIFICATION AND DESCRIPTION
  - ORIENTATION DATA
  - ENGINEERING CLASSIFICATION AND DESCRIPTION
  - SAMPLE DATA
  - TEST DATA

**Sample Data**

- **Number of Blows / 6":**
  - ELEVATION, feet
  - DEPTH, ft
  - GRAPHIC LOG
  - GEOLOGICAL CLASSIFICATION AND DESCRIPTION
  - ORIENTATION DATA
  - ENGINEERING CLASSIFICATION AND DESCRIPTION
  - SAMPLE DATA
  - TEST DATA

**Test Data**

- **Driving Weight, lbs:**
  - ELEVATION, feet
  - DEPTH, ft
  - GRAPHIC LOG
  - GEOLOGICAL CLASSIFICATION AND DESCRIPTION
  - ORIENTATION DATA
  - ENGINEERING CLASSIFICATION AND DESCRIPTION
  - SAMPLE DATA
  - TEST DATA

- **Moisture Content, %:**
  - ELEVATION, feet
  - DEPTH, ft
  - GRAPHIC LOG
  - GEOLOGICAL CLASSIFICATION AND DESCRIPTION
  - ORIENTATION DATA
  - ENGINEERING CLASSIFICATION AND DESCRIPTION
  - SAMPLE DATA
  - TEST DATA

- **Sample Weight, lb:**
  - ELEVATION, feet
  - DEPTH, ft
  - GRAPHIC LOG
  - GEOLOGICAL CLASSIFICATION AND DESCRIPTION
  - ORIENTATION DATA
  - ENGINEERING CLASSIFICATION AND DESCRIPTION
  - SAMPLE DATA
  - TEST DATA

- **Advisory Tests:**
  - ELEVATION, feet
  - DEPTH, ft
  - GRAPHIC LOG
  - GEOLOGICAL CLASSIFICATION AND DESCRIPTION
  - ORIENTATION DATA
  - ENGINEERING CLASSIFICATION AND DESCRIPTION
  - SAMPLE DATA
  - TEST DATA

---

**Drill Hole DH- 4**
### Geological Classification and Description

<table>
<thead>
<tr>
<th>Depth, ft</th>
<th>Silty Sand (SM)</th>
<th>Sandy Silt (ML)</th>
<th>Poorly Graded Sand (SP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>65</td>
<td>Light grayish brown, damp, medium dense, fine grained sand</td>
<td>Light brown, very moist, stiff, some free water noticed in sampler, possible perched water above</td>
<td>Light brown, light gray, and gray, very moist, medium dense, fine grained sand</td>
</tr>
<tr>
<td>70</td>
<td>Becomes brown</td>
<td></td>
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<tr>
<td>75</td>
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### Additional Tests

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<th>Dry Unit Weight, pcf</th>
<th>Elevation, feet</th>
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### Engineering Classification and Description

<table>
<thead>
<tr>
<th>Sample</th>
<th>Number of Blows / 6&quot;</th>
<th>Driving Weight, lbs</th>
<th>Moisture Content, %</th>
<th>Dry Unit Weight, pcf</th>
<th>Elevation, feet</th>
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**Project Location:** 200 City Boulevard West

**Project Number:** 17-176-00

**Log of Drill Hole DH-4**
<table>
<thead>
<tr>
<th>ELEVATION, feet</th>
<th>DEPTH, feet</th>
<th>GRAPHIC LOG</th>
<th>GEOLOGICAL CLASSIFICATION AND DESCRIPTION</th>
<th>ORIENTATION DATA</th>
<th>ENGINEERING CLASSIFICATION AND DESCRIPTION</th>
<th>SAMPLE DATA</th>
<th>TEST DATA</th>
</tr>
</thead>
<tbody>
<tr>
<td>60</td>
<td></td>
<td></td>
<td>SANDY SILT (ML); brown, very moist to saturated, stiff</td>
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<td>3</td>
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<tr>
<td></td>
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### Log of Drill Hole DH-5

**Project Location:** 200 City Boulevard West  
**Project Number:** 17-176-00  
**Date(s) Drilled:** 9/28/2017  
**Drilling Method:** Hollow Stem Auger  
**Drill Rig:** Marl M12  
**Groundwater Depth:** Not Encountered [0.0]  
**Sampling Method(s):** California Modified, SPT, & Bulk  
**Remarks:** Driving Method and Drop Auto Hammer

#### Geological Classification and Description

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<thead>
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<th>Elevation, feet</th>
<th>Geological Classification and Description</th>
<th>Orientation Data</th>
<th>Engineering Classification and Description</th>
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<td>115-15</td>
<td>Artificial Fill (Qaf)</td>
<td></td>
<td>Asphalt Concrete (approximately 4 inches)</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Silty Sand (SM); light gray-brown, moist, very loose, medium grained sand</td>
</tr>
<tr>
<td>120-10</td>
<td>Alluvial Fan Deposits (Qaf)</td>
<td></td>
<td>Poorly Graded Sand With Silt (SP-SM); light brown to gray brown, moist, very loose to medium dense becomes medium dense</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Poorly Graded Sand (SP); light brown, moist, medium dense, fine- to coarse-grained sand</td>
</tr>
<tr>
<td></td>
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<td>Zones of Clayey Silt (ML) ~ 1&quot; thick within sampler</td>
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#### Additional Tests

<table>
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<tr>
<td>Number of Blows / 6&quot;</td>
<td>Moisture Content, %</td>
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<tr>
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<td>Density, %</td>
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**Remarks:**
- **Remarks:** Driving Method and Drop Auto Hammer

**Backfill:** Native

**Total Depth of Drill Hole:** 26.5 feet

**Approx. Surface Elevation, ft MSL:** 130.0
<table>
<thead>
<tr>
<th>ELEVATION, feet</th>
<th>DEPTH, feet</th>
<th>GRAPHIC LOG</th>
<th>GEOLOGICAL CLASSIFICATION AND DESCRIPTION</th>
<th>ORIENTATION DATA</th>
<th>ENGINEERING CLASSIFICATION AND DESCRIPTION</th>
<th>SAMPLE DATA</th>
<th>TEST DATA</th>
</tr>
</thead>
<tbody>
<tr>
<td>105</td>
<td></td>
<td></td>
<td>SANDY SILT (ML); grayish brown, very moist to saturated, stiff, fine grained sand, tip of sampler has some free water, possible perched water from above</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>25</td>
<td></td>
<td></td>
<td>POORLY GRADED SAND (SP); white, light brown, and gray, damp to moist, medium dense, fine to coarse grained sand</td>
<td></td>
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<td></td>
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</table>

**Additional Tests**

- Sample
- Number of Blistes / 6":
  - Sample 1: 10
  - Sample 2: 8
  - Sample 3: 6
- Driving Weight, lbs:
  - Sample 1: 13
  - Sample 2: 12
  - Sample 3: 16
- Moisture Content, %:
  - Sample 1: 99
**Log of Drill Hole DH-6**

**Sheet 1 of 2**

<table>
<thead>
<tr>
<th>ELEVATION, feet</th>
<th>DEPTH, feet</th>
<th>GEOLOGICAL CLASSIFICATION AND DESCRIPTION</th>
<th>ORIENTATION DATA</th>
<th>ENGINEERING CLASSIFICATION AND DESCRIPTION</th>
<th>SAMPLE DATA</th>
<th>TEST DATA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>ARTIFICIAL FILL (Qaf)</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>ALLUVIAL FAN DEPOSITS (Qvf)</td>
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<td></td>
</tr>
<tr>
<td>125</td>
<td>5</td>
<td>Asphalt Concrete (approximately 4 inches)</td>
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<td></td>
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<td></td>
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<tr>
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<td>10</td>
<td>SILTY SAND (SM); gray-brown, damp, loose, medium grained sand</td>
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<td></td>
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<tr>
<td>115</td>
<td>15</td>
<td>POORLY GRADED SAND WITH SILT (SP-SM); light gray-brown, moist, firm, fine-grained sand</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>110</td>
<td>20</td>
<td>POORLY GRADED SAND (SP); light gray-brown, dry, medium dense, fine to coarse grained sand</td>
<td></td>
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**Date(s) Drilled:** 9/28/2017  
**Logged By:** MTF  
**Checked By:** NS

**Drilling Method:** Hollow Stem Auger  
**Drilling Contractor:** Gregg Drilling  
**Total Depth of Drill Hole:** 26.5 feet

**Drill Rig Type:** Marl M12  
**Diameter(s) of Hole, inches:** 8"  
**Approx. Surface Elevation, ft MSL:** 130.0

**Groundwater Depth [Elevation], feet:** Not Encountered [0.0]  
**Sampling Method(s):** California Modified, SPT, & Bulk  
**Drill Hole Backfill:** Native

**Remarks:** Driving Method and Drop Auto Hammer

**Project Location:** 200 City Boulevard West  
**Project Number:** 17-176-00

**Project:** Terrace Apartments Expansion Log of Drill Hole DH-6

**Sheet 1 of 2**

**Sample Data**

**Test Data**

**Sample:** Number of Blows / 6"  
**Driving Weight, lbs:**  
**Moisture Content, %:**  
**Drum Weight, pcf:**  
**Additional Tests:**
<table>
<thead>
<tr>
<th>ELEVATION, ft</th>
<th>DEPTH, ft</th>
<th>GRAPHIC LOG</th>
<th>GEOLOGICAL CLASSIFICATION AND DESCRIPTION</th>
<th>ORIENTATION DATA</th>
<th>ENGINEERING CLASSIFICATION AND DESCRIPTION</th>
<th>SAMPLE DATA</th>
<th>TEST DATA</th>
</tr>
</thead>
<tbody>
<tr>
<td>105</td>
<td>25</td>
<td></td>
<td>SANDY SILT (ML); grayish brown, very moist, firm, fine-grained sand</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
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</tr>
</tbody>
</table>

**Project Location:** 200 City Boulevard West
**Project Number:** 17-176-00

---

**Log of Drill Hole DH-6**
**Log of Drill Hole DH- 7**

**Project Location:** 200 City Boulevard West  
**Project Number:** 17-176-00

<table>
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<tr>
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<th>Checked By</th>
<th>NS</th>
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<td>9/29/2017</td>
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<tr>
<th>Drilling Method</th>
<th>Hollow Stem Auger</th>
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<th>Gregg Drilling</th>
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</table>

<table>
<thead>
<tr>
<th>Drill Rig Type</th>
<th>Marl M12</th>
<th>Diameter(s) of Hole, inches</th>
<th>8&quot;</th>
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<table>
<thead>
<tr>
<th>Groundwater Depth</th>
<th>Not Encountered</th>
<th>[0.0]</th>
<th>Sampling Method(s)</th>
<th>California Modified, SPT, &amp; Bulk</th>
<th>Drill Hole Backfill</th>
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<table>
<thead>
<tr>
<th>Remarks</th>
<th></th>
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<th>Driving Method and Drop</th>
<th>Auto Hammer</th>
</tr>
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**GEOLOGICAL CLASSIFICATION AND DESCRIPTION**

- **ARTIFICIAL FILL (Qaf)**
  - Asphalt Concrete (approximately 5 inches)
  - SILTY SAND (SM); light gray-brown, damp, medium dense, fine-to-medium coarse-grained sand

- **ALLUVIAL FAN DEPOSITS (Qvf)**
  - POORLY GRADED SAND WITH SILT (SP-SM); light brown, moist, medium dense, fine-to-coarse-grained sand
  - POORLY GRADED SAND (SP); light gray-brown, damp, medium dense, fine-to-coarse-grained sand

**ORIENTATION DATA**

**ENGINEERING CLASSIFICATION AND DESCRIPTION**

**SAMPLE DATA**

<table>
<thead>
<tr>
<th>Sample</th>
<th>Number of Blows / 6&quot;</th>
<th>Driving Weight, lbs</th>
<th>Moisture Content, %</th>
<th>Dry Density, pcf</th>
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<tr>
<th>Sample</th>
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<th>Driving Weight, lbs</th>
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</tbody>
</table>

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**DRILL HOLE**

**ELEVATION, feet**

**GRAPHIC LOG**

**PROJECT LOCATION:** 200 City Boulevard West

**PROJECT NUMBER:** 17-176-00

**PROJECT:** Terrace Apartments Expansion

**Log of Drill Hole DH- 7**

**Sampling Method(s):** California Modified, SPT, & Bulk

**Backfill:** Native

**Auto Hammer**
<table>
<thead>
<tr>
<th>ELEVATION, ft</th>
<th>DEPTH, ft</th>
<th>GRAPHIC LOG</th>
<th>GEOLOGICAL CLASSIFICATION AND DESCRIPTION</th>
<th>ORIENTATION DATA</th>
<th>ENGINEERING CLASSIFICATION AND DESCRIPTION</th>
<th>SAMPLE DATA</th>
<th>TEST DATA</th>
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<tbody>
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<td></td>
<td></td>
<td>becomes dense</td>
<td></td>
<td>13 19 35</td>
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<td>SILTY SAND (SM); brown, moist, medium</td>
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<td>5 11 15</td>
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Project Location: 200 City Boulevard West
Project Number: 17-176-00

Log of Drill Hole DH-7
Sheet 2 of 2
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<th>DEPTH, feet</th>
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<th>ORIENTATION DATA</th>
<th>ENGINEERING CLASSIFICATION AND DESCRIPTION</th>
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<tbody>
<tr>
<td>125</td>
<td>-5</td>
<td>ARTIFICIAL FILL (Qaf)</td>
<td></td>
<td>SILTY SAND (SM); gray, moist to very moist,</td>
</tr>
<tr>
<td></td>
<td></td>
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<td>loose, fine- to medium coarse-grained sand</td>
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<td>ELEVATION, feet</td>
<td>DEPTH, feet</td>
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<td>ORIENTATION DATA</td>
<td>ENGINEERING CLASSIFICATION AND DESCRIPTION</td>
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<td>ARTIFICIAL FILL (Qaf)</td>
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<td>SILTY SAND (SM); gray brown, moist to very moist, loose, fine to medium grained sand</td>
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<tr>
<td>120</td>
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<td>ALLUVIAL FAN DEPOSITS (Qvf)</td>
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<td>SILTY SAND (SM); light gray brown, moist, loose to medium dense, fine to coarse grained sand</td>
</tr>
<tr>
<td>115</td>
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Drill Hole DH- 9
# Log of Drill Hole DH-10

**Date(s) Drilled:** 9/28/2017  
**Logged By:** MTF  
**Checked By:** NS  
**Drilling Method:** Hollow Stem Auger  
**Drilling Contractor:** Gregg Drilling  
**Total Depth of Drill Hole:** 10.5 feet  
**Drill Rig Type:** Marl M12  
**Diameter(s) of Hole, inches:** 8"  
**Approx. Surface Elevation, ft MSL:** 131.0  
**Groundwater Depth [Elevation], feet:** Not Encountered [0.0]  
**Sampling Method(s):** California Modified, SPT, & Bulk Density  
**Drill Hole Backfill:** Native  
**Remark:** Driving Method and Drop: Auto Hammer

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<th>ORIENTATION DATA</th>
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### Log of Drill Hole DH-11

**Date(s) Drilled:** 9/28/2017
**Logged By:** MTF
**Checked By:** NS

**Drilling Method:** Hollow Stem Auger
**Drilling Contractor:** Gregg Drilling
**Total Depth of Drill Hole:** 5.0 feet

**Drill Rig Type:** Marl M12
**Diameter(s) of Hole, inches:** 6"
**Approx. Surface Elevation, ft MSL:** 131.0

**Groundwater Depth [Elevation], feet:** Not Encountered [0.0]
**Sampling Method(s):** California Modified, SPT, & Bulk
**Drill Hole Backfill:** Native

**Remarks:** Driving Method and Drop

### SAMPLE DATA

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<th>ORIENTATION DATA</th>
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**ADDITIONAL TESTS**

**DEEP BORE DATA**

- **Project Location:** 200 City Boulevard West
- **Project Number:** 17-176-00
- **Project:** Terrace Apartments Expansion Log of Drill Hole DH-11

![GMU Geotechnical Inc. Logo]
APPENDIX A-1

Cone Penetration Testing Data by GMU Geotechnical, Inc.
CPT: CPT-05
Total depth: 50.36 ft, Date: 10/26/2017
Surface Elevation: 0.00 ft
Coords: X:0.00, Y:0.00
Cone Type: Unknown
Cone Operator: Unknown

- Tip resistance (tsf)
- Cone resistance qt
- Depth (ft)
- Friction ratio
- Pore pressure u
- SBT Index
- Soil Behaviour Type

**Project:** Terrace Apartments Expansion
**Location:** Orange, CA

**Total depth:** 50.36 ft, **Date:** 10/26/2017
**Surface Elevation:** 0.00 ft
**Coords:** X:0.00, Y:0.00

**Cone Type:** Unknown
**Cone Operator:** Unknown

**Cone resistance qt**

**Friction ratio**

**Pore pressure u**

**SBT Index**

**Soil Behaviour Type**

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty clay
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to clayey sand
9. Very stiff fine grained

**SBT legend**

- **1. Sensitive fine grained**
- **2. Organic material**
- **3. Clay to silty clay**
- **4. Clayey silt to silty clay**
- **5. Silty sand to sandy silt**
- **6. Clean sand to silty sand**
- **7. Gravely sand to sand**
- **8. Very stiff sand to clayey sand**
- **9. Very stiff fine grained**

CPT-IT v.2.0.1.66 - CPTU data presentation & interpretation software - Report created on: 11/7/2017, 11:12:18 AM
Project file: U:\2017\17-176-00 Terraces Apartments Geotechnical Investigation\Analyses\Settlement\Terrace Apts C-PeTiT.cpt
APPENDIX B

Geotechnical Laboratory Procedures and Test Results by GMU Geotechnical, Inc.
APPENDIX B

GMU GEOTECHNICAL LABORATORY PROCEDURES AND TEST RESULTS

MOISTURE AND DENSITY

Field moisture content and in-place density were determined for selected 6-inch sample sleeve of undisturbed soil material obtained from the drill holes. The field moisture content was determined in general accordance with ASTM Test Method D 2216 by obtaining one-half the moisture sample from each end of the 6-inch sleeve. The in-place dry density of the sample was determined by using the wet weight of the entire sample.

At the same time the field moisture content and in-place density were determined, the soil material at each end of the sleeve was classified according to the Unified Soil Classification System. The results of the field moisture content and in-place density determinations are presented on the right-hand column of the Log of Drill Hole and are summarized on Table B-1. The results of the visual classifications were used for general reference.

PARTICLE SIZE DISTRIBUTION

As part of the engineering classification of the materials underlying the site, some samples were tested to determine the distribution of particle sizes. The distribution was determined in general accordance with ASTM Test Method D 422 using U.S. Standard Sieve Openings 3", 1.5", 3/4, 3/8, and U.S. Standard Sieve Nos. 4, 10, 20, 40, 60, 100, and 200. In addition, on some samples a standard hydrometer test was performed to determine the distribution of particle sizes passing the No. 200 sieve (i.e., silt and clay-size particles). The results of the tests are contained in this Appendix B. Key distribution categories (% gravel; % sand, etc.) are contained on Table B-1.

ATTERBERG LIMITS

As part of the engineering classification of the soil material, some samples of the on-site soil material were tested to determine relative plasticity. This relative plasticity is based on the Atterberg limits determined in general accordance with ASTM Test Method D 4318. The results of these tests are contained in this Appendix B and also Table B-1.

CHEMICAL TESTS

The corrosion potential of typical on-site materials under long-term contact with both metal and concrete was determined by chemical and electrical resistance tests. The soluble sulfate test for
potential concrete corrosion was performed in general accordance with California Test Method 417, the minimum resistivity test for potential metal corrosion was performed in general accordance with California Test Method 643, and the concentration of soluble chlorides was determined in general accordance with California Test Method 422. The results of these tests are contained in Table B-1.

COMPACTION TESTS

A bulk sample representative of the on-site materials was tested to determine the maximum dry density and optimum moisture content of the soil. These compactive characteristics were determined in general accordance with ASTM Test Method D 1557. The results of this test are contained in this Appendix B and also Table B-1.

CONSOLIDATION TESTS

The one-dimensional consolidation properties of “undisturbed” samples were evaluated in general accordance with the provisions of ASTM Test Method D 2435. Sample diameter was 2.416 inches and sample height was 1.00 inch. Water was added during the test at various normal loads to evaluate the potential for hydro-collapse and to produce saturation during the remainder of the testing. Consolidation readings were taken regularly during each load increment until the change in sample height was less than approximately 0.0001 inch over a two-hour period. The graphic presentation of consolidation data is a representation of volume change in change in axial load. The results of these tests are contained in this Appendix B.

DIRECT SHEAR STRENGTH TESTS

Direct shear tests were performed on typical on-site materials. The general philosophy and procedure of the tests were in accord with ASTM Test Method D 3080 - “Direct Shear Tests for Soils Under Consolidated Drained Conditions”.

The tests are single shear tests and are performed using a sample diameter of 2.416 inches and a height of 1.00 inch. The normal load is applied by a vertical dead load system. A constant rate of strain is applied to the upper one-half of the sample until failure occurs. Shear stress is monitored by a strain gauge-type precision load cell and deflection is measured with a digital dial indicator. This data is transferred electronically to data acquisition software which plots shear strength vs. deflection. The shear strength plots are then interpreted to determine either peak or ultimate shear strengths. Residual strengths were obtained through multiple shear box reversals. A strain rate compatible with the grain size distribution of the soils was utilized. The interpreted results of these tests are shown in this Appendix B.
R-VALUE TESTS

A bulk sample representative of the underlying on-site materials was tested to measure the response of a compacted sample to a vertically applied pressure under specific conditions. The R-value of a material is determined when the material is in a state of saturation such that water will be exuded from the compacted test specimen when a 16.8 kN load (2.07 MPa) is applied. The results from these test procedures are reported in Table B-1.
## TABLE B-1

### SUMMARY OF SOIL LABORATORY DATA

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<tr>
<th>Sample Information</th>
<th>USCS Group Symbol</th>
<th>In Situ Water Content, %</th>
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<th>In Situ Saturation, %</th>
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<th>Sand, %</th>
<th>#&lt;200, %</th>
<th>&lt;2µ, %</th>
<th>LL</th>
<th>PL</th>
<th>PI</th>
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<th>Optimum Water Content, %</th>
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Project: Terrace Apartments Expansion
Project No. 17-176-00
### TABLE B-1
SUMMARY OF SOIL LABORATORY DATA

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<tr>
<th>Sample Information</th>
<th>In Situ Water Content, %</th>
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<tr>
<td>DH-6</td>
<td>10</td>
<td>120.0</td>
<td>Qyf</td>
<td>SP</td>
<td>1.3</td>
<td>104</td>
<td>10</td>
</tr>
<tr>
<td>DH-7</td>
<td>0</td>
<td>124.0</td>
<td>Qaf</td>
<td>SM</td>
<td>12.5</td>
<td>98</td>
<td>9</td>
</tr>
<tr>
<td>DH-7</td>
<td>2.5</td>
<td>121.5</td>
<td>Qyf</td>
<td>SP-SM</td>
<td>3.2</td>
<td>103</td>
<td>14</td>
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<tr>
<td>DH-7</td>
<td>10</td>
<td>114.0</td>
<td>Qyf</td>
<td>SP</td>
<td>1.9</td>
<td>105</td>
<td>9</td>
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<tr>
<td>DH-9</td>
<td>5</td>
<td>123.0</td>
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<td>SM</td>
<td>9.1</td>
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<td>32</td>
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<tr>
<td>DH-10</td>
<td>5</td>
<td>126.0</td>
<td>Qyf</td>
<td>SP</td>
<td>3.2</td>
<td>98</td>
<td>12</td>
</tr>
</tbody>
</table>
### ATTERBERG LIMITS

**Project:** Terrace Apartments Expansion  
**Project No.:** 17-176-00

---

**Boring Number** | **Depth (feet)** | **Geologic Unit** | **Test Symbol** | **Water Content (%)** | **LL** | **PL** | **PI** | **Classification**
---|---|---|---|---|---|---|---|---
DH-1 | 30.0 | Qyf | ⬤ | 28 | 21 | 7 | SANDY SILTY CLAY (CL-ML)
DH-1 | 50.0 | Qyf | ▲ | 39 | 23 | 16 | SANDY CLAY (CL)
DH-3 | 35.0 | Qyf | ▲ | 19 | 35 | 20 | SANDY CLAY (CL)

---
PARTICLE SIZE DISTRIBUTION

Project: Terrace Apartments Expansion
Project No. 17-176-00

<table>
<thead>
<tr>
<th>Boring Number</th>
<th>Depth (feet)</th>
<th>Geologic Unit</th>
<th>Symbol</th>
<th>LL</th>
<th>PI</th>
<th>Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>DH- 1</td>
<td>30.0</td>
<td>Qyf</td>
<td>●</td>
<td>28</td>
<td>7</td>
<td>SANDY SILTY CLAY (CL-ML)</td>
</tr>
<tr>
<td>DH- 3</td>
<td>35.0</td>
<td>Qyf</td>
<td>□</td>
<td>35</td>
<td>15</td>
<td>SANDY CLAY (CL)</td>
</tr>
<tr>
<td>DH- 5</td>
<td>2.5</td>
<td>Qyf</td>
<td>▲</td>
<td></td>
<td></td>
<td>POORLY GRADED SAND WITH SILT (SP-SM)</td>
</tr>
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</table>
COMPACTION TEST DATA

Project: Terrace Apartments Expansion
Project No. 17-176-00

<table>
<thead>
<tr>
<th>Boring Number</th>
<th>Depth (feet)</th>
<th>Geologic Unit</th>
<th>Symbol</th>
<th>Maximum Dry Density, pcf</th>
<th>Optimum Moisture Content, %</th>
<th>Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>DH- 6</td>
<td>0.0</td>
<td>Qaf</td>
<td>●</td>
<td>124</td>
<td>11</td>
<td>SILT SAND (SM)</td>
</tr>
<tr>
<td>DH- 7</td>
<td>0.0</td>
<td>Qaf</td>
<td>□</td>
<td>125</td>
<td>7.5</td>
<td>SILTY SAND (SM)</td>
</tr>
</tbody>
</table>
SAMPLE AND TEST DESCRIPTION

Sample Location: DH- 3  @  15.0 ft  
Geologic Unit: Qyf  
Classification: POORLY GRADED SAND WILT SILT (SP-S)
Strain Rate (in/min): 0.005  
Sample Preparation: Undisturbed
Notes: Sample saturated prior and during shearing

STRENGTH PARAMETERS

<table>
<thead>
<tr>
<th>STRENGTH TYPE</th>
<th>COHESION (psf)</th>
<th>FRICTION ANGLE (degrees)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak Strength</td>
<td>45</td>
<td>36.0</td>
</tr>
<tr>
<td>Ultimate Strength</td>
<td>40</td>
<td>30.0</td>
</tr>
</tbody>
</table>

SHEAR TEST DATA

Project: Terrace Apartments Expansion
Project No. 17-176-00
**SAMPLE AND TEST DESCRIPTION**

Sample Location: DH- 3 @ 35.0 ft  
Geologic Unit: Qyf  
Classification: SANDY CLAY (CL)  
Strain Rate (in/min): 0.005  
Sample Preparation: Undisturbed  
Notes: Sample saturated prior and during shearing

---

**STRENGTH PARAMETERS**

<table>
<thead>
<tr>
<th>STRENGTH TYPE</th>
<th>COHESION (psf)</th>
<th>FRICTION ANGLE (degrees)</th>
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</thead>
<tbody>
<tr>
<td>Peak Strength</td>
<td>245</td>
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<tr>
<td>Ultimate Strength</td>
<td>210</td>
<td>25.0</td>
</tr>
</tbody>
</table>

---

**SHEAR TEST DATA**

Project: Terrace Apartments Expansion  
Project No. 17-176-00
SAMPLE AND TEST DESCRIPTION

Sample Location: DH-4 @ 35.0 ft
Geologic Unit: Qyf
Classification: SANDY CLAY (CL)
Strain Rate (in/min): 0.005
Sample Preparation: Undisturbed
Notes: Sample saturated prior and during shearing

STRENGTH PARAMETERS

<table>
<thead>
<tr>
<th>STRENGTH TYPE</th>
<th>COHESION (psf)</th>
<th>FRICTION ANGLE (degrees)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak Strength</td>
<td>525</td>
<td>27.0</td>
</tr>
<tr>
<td>Ultimate Strength</td>
<td>515</td>
<td>24.0</td>
</tr>
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</table>

SHEAR TEST DATA

Project: Terrace Apartments Expansion
Project No. 17-176-00
SAMPLE AND TEST DESCRIPTION

Sample Location: DH-6 @ 2.5 ft  Geologic Unit: Qyf  Classification: POORLY GRADED SAND WITH SILT (SP-S)
Strain Rate (in/min): 0.005  Sample Preparation: Undisturbed
Notes: Sample saturated prior and during shearing

STRENGTH PARAMETERS

<table>
<thead>
<tr>
<th>STRENGTH TYPE</th>
<th>COHESION (psf)</th>
<th>FRICTION ANGLE (degrees)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak Strength</td>
<td>110</td>
<td>30.0</td>
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<tr>
<td>Ultimate Strength</td>
<td>110</td>
<td>30.0</td>
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</table>

SHEAR TEST DATA

Project: Terrace Apartments Expansion
Project No. 17-176-00
**SAMPLE AND TEST DESCRIPTION**

Sample Location: DH-7 @ 2.5 ft
Geologic Unit: Qyf
Classification: POORLY GRADED SAND WITH SILT (SP-S)
Strain Rate (in/min): 0.005
Sample Preparation: Undisturbed
Notes: Sample saturated prior and during shearing

**STRENGTH PARAMETERS**

<table>
<thead>
<tr>
<th>STRENGTH TYPE</th>
<th>COHESION (psf)</th>
<th>FRICTION ANGLE (degrees)</th>
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</thead>
<tbody>
<tr>
<td>Peak Strength</td>
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<td>31.0</td>
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<tr>
<td>Ultimate Strength</td>
<td>75</td>
<td>31.0</td>
</tr>
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**SHEAR TEST DATA**

Project: Terrace Apartments Expansion
Project No. 17-176-00
CONSOLIDATION TEST DATA

Project: Terrace Apartments Expansion
Project No. 17-176-00

<table>
<thead>
<tr>
<th>Boring Number</th>
<th>Depth (feet)</th>
<th>Geologic Unit</th>
<th>Symbol</th>
<th>In Situ or Remolded Sample</th>
<th>% Hydro-Collapse</th>
<th>Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>DH-1</td>
<td>35.0</td>
<td>Qyf</td>
<td>●</td>
<td>In Situ</td>
<td>-0.11</td>
<td>SILTY CLAY (CL)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>□</td>
<td>In Situ</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>▲</td>
<td>In Situ</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>★</td>
<td>In Situ</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

W = water added
CONsolidation test data

project: terrace Apartments Expansion
Project No. 17-176-00

<table>
<thead>
<tr>
<th>boring Number</th>
<th>Depth (feet)</th>
<th>geologic Unit</th>
<th>symbol</th>
<th>in situ or remolded Sample</th>
<th>% Hydro-Collapse</th>
<th>classification</th>
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</thead>
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<tr>
<td>DH-4</td>
<td>35.0</td>
<td>Qyf</td>
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<td>in situ</td>
<td>-0.08</td>
<td>Sandy clay (cl)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>▼</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>▲</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>★</td>
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</tbody>
</table>
APPENDIX C

Liquefaction Analysis
Overall Parametric Assessment Method

Settlements vs PGA

<table>
<thead>
<tr>
<th>CPT Name</th>
<th>Settlements (in)</th>
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<tbody>
<tr>
<td>CPT-01</td>
<td>0.17</td>
</tr>
<tr>
<td>CPT-02</td>
<td>0.16</td>
</tr>
<tr>
<td>CPT-03</td>
<td>0.15</td>
</tr>
<tr>
<td>CPT-04</td>
<td>0.14</td>
</tr>
<tr>
<td>CPT-05</td>
<td>0.13</td>
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<tr>
<td>CPT-06</td>
<td>0.12</td>
</tr>
<tr>
<td>CPT-07</td>
<td>0.11</td>
</tr>
</tbody>
</table>

:: CPT main liquefaction parameters details ::

<table>
<thead>
<tr>
<th>CPT Name</th>
<th>Earthquake Mag.</th>
<th>Earthquake Accel.</th>
<th>GWT in situ (ft)</th>
<th>GWT earthq. (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPT-01</td>
<td>6.60</td>
<td>0.53</td>
<td>90.00</td>
<td>50.00</td>
</tr>
<tr>
<td>CPT-02</td>
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<td>90.00</td>
<td>50.00</td>
</tr>
<tr>
<td>CPT-03</td>
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<td>50.00</td>
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<td>0.53</td>
<td>90.00</td>
<td>50.00</td>
</tr>
<tr>
<td>CPT-06</td>
<td>6.60</td>
<td>0.53</td>
<td>90.00</td>
<td>50.00</td>
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<tr>
<td>CPT-07</td>
<td>6.60</td>
<td>0.53</td>
<td>90.00</td>
<td>50.00</td>
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</table>
Project title: Terrace Apartments Expansion
CPT file: CPT-01
Location: Orange, CA

Input parameters and analysis data

- Fines correction method: NCEER (1998)
- Points to test: Based on Ic value
- Earthquake magnitude Mw: 6.60
- Peak ground acceleration: 0.53

- Use fill: No
- Fill height: N/A
- Fill weight: N/A
- Trans. detect. applied: Yes
- Kσ applied: Yes
- MSF method: Method based

Cone resistance

Friction Ratio

SBTn Plot

CRR plot

FS Plot

Summary of liquefaction potential

Zone A1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry
**CPT basic interpretation plots (normalized)**

**Input parameters and analysis data**

- **Analysis method**: NCEER (1998)
- **Fines correction method**: NCEER (1998)
- **Points to test**: Based on Ic value
- **Earthquake magnitude Mw**: 6.60
- **Peak ground acceleration**: 0.53
- **Depth to water table (ertq.)**: 50.00 ft
- **Average results interval**: 1
- **Ic cut-off value**: 2.60
- **Unit weight calculation**: Based on SBT
- **Use fill**: No
- **Fill height**: N/A
- **Depth to water table (insitu)**: 90.00 ft
- **Fill weight**: N/A
- **Transition detect. applied**: Yes
- **Kσ applied**: Yes
- **Clay like behavior applied**: Sands only
- **Fill weight**: N/A
- **Limit depth applied**: No
- **Limit depth**: N/A

**SBTn legend**

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty sand
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to sand
9. Very stiff fine grained

**SBTn Plot**

- **Norm. Soil Behaviour Type**
  - Sand & silty sand
  - clay & silty clay
  - Clay
  - Clay

**CLiq v.2.1.6.11 - CPT Liquefaction Assessment Software - Report created on: 11/17/2017, 8:27:57 AM**

Project file: U:\2017\17-176-00 Terraces Apartments Geotechnical Investigation\Analyses\Liquefaction\CLIQ_TERRACE APTS.clq
Liquefaction analysis overall plots

Input parameters and analysis data

- Fines correction method: NCEER (1998)
- Points to test: Based on Ic value
- Earthquake magnitude $M_w$: 6.6
- Peak ground acceleration: 0.53
- Depth to water table (erthq.): 50.00 ft
- Average results interval: 1
- Ic cut-off value: 2.60
- Unit weight calculation: Based on SBT
- Use fill: No
- Fill height: N/A
- Fill weight: N/A
- Transition detect. applied: Yes
- Clay like behavior applied: Sands only
- Limit depth applied: No
- Limit depth: N/A

F.S. color scheme
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

LPI color scheme
- Very high risk
- High risk
- Low risk
LIQUEFACTION ANALYSIS REPORT

Project title: Terrace Apartments Expansion
CPT file: CPT-02
Location: Orange, CA

Input parameters and analysis data

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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<tbody>
<tr>
<td>Analysis method</td>
<td>NCEER (1998)</td>
</tr>
<tr>
<td>Fines correction method</td>
<td>NCEER (1998)</td>
</tr>
<tr>
<td>Points to test</td>
<td>Based on Ic value</td>
</tr>
<tr>
<td>Earthquake magnitude Mw</td>
<td>6.60</td>
</tr>
<tr>
<td>Peak ground acceleration</td>
<td>0.53</td>
</tr>
<tr>
<td>G.W.T. (in-situ)</td>
<td>90.00 ft</td>
</tr>
<tr>
<td>G.W.T. (earthq.)</td>
<td>50.00 ft</td>
</tr>
<tr>
<td>Average results interval</td>
<td>1</td>
</tr>
<tr>
<td>Ic cut-off value</td>
<td>2.60</td>
</tr>
<tr>
<td>Unit weight calculation</td>
<td>Based on SBT</td>
</tr>
</tbody>
</table>

Use fill: No  Clay like behavior applied: Sands only
Fill height: N/A  Limit depth applied: No
Fill weight: N/A  Limit depth: N/A
Trans. detect. applied: Yes  MSF method: Method based
K$_a$ applied: Yes

Summary of liquefaction potential

Zone A$_1$: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A$_2$: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

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Project file: U:\2017\17-176-00 Terraces Apartments Geotechnical Investigation\Analyses\Liquefaction\CLIQ_TERRACE APTS.clq
CPT basic interpretation plots

Cone resistance

Friction Ratio

Pore pressure

SBT Plot

Soil Behaviour Type

Input parameters and analysis data

Fines correction method: NCEER (1998)
Points to test: Based on Ic value
Earthquake magnitude Mw: 6.60
Peak ground acceleration: 0.53
Depth to water table (erthq.): 50.00 ft
Depth to water table (insitu): 90.00 ft
Average results interval: 1
Ic cut-off value: 2.60
Transition detect. applied: Yes
Kσ applied: Yes
Fill weight: N/A
Fill height: N/A
Limit depth applied: No
Limit depth: N/A

SBT legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty sand
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Very dense stiff soil
8. Very stiff sand to gravelly sand
9. Very stiff fine grained
10. Sand & silty sand
11. Silty sand & sandy silt
12. Clay & silty clay
13. Clay
**CPT basic interpretation plots (normalized)**

**Norm. cone resistance**
- Qtn vs Depth (ft)

**Norm. friction ratio**
- Fr (%) vs Depth (ft)

**Nom. pore pressure ratio**
- Bq vs Depth (ft)

**SBTn Plot**
- Ic (Robertson 1990)

**Norm. Soil Behaviour Type**
- Clay
- Sand & silty sand
- Silty sand & sandy silt
- Clay & silty clay
- Organic soil

**Input parameters and analysis data**
- Fines correction method: NCEER (1998)
- Points to test: Based on Ic value
- Earthquake magnitude Mw: 6.60
- Peak ground acceleration: 0.53
- Depth to water table (ethq.): 90.00 ft

- Fines correction factor: 1
- Clayey silt to silty sand
- Clean sand to silty sand
- Gravely sand to sand
- Very stiff fine grained

- Fill weight: N/A
- Transition detect. applied: Yes
- Ic cut-off value: 2.60
- Kσ applied: Yes
- Limit depth applied: No
- SBTn legend:
  - 1. Sensitive fine grained
  - 2. Organic material
  - 3. Clay to silty clay
  - 4. Clayey silt to silty sand
  - 5. Silty sand to sandy silt
  - 6. Clean sand to silty sand
  - 7. Gravelly sand to sand
  - 8. Very stiff sand to
  - 9. Very stiff fine grained

---

CLiq v.2.1.6.11 - CPT Liquefaction Assessment Software - Report created on: 11/17/2017, 8:27:57 AM
Project file: U:\2017\17-176-00 Terraces Apartments Geotechnical Investigation\Analyses\Liquefaction\CLIQ_TERRACE APTS.clq
Liquefaction analysis overall plots

Input parameters and analysis data

Fines correction method: NCEER (1998)
Points to test: Based on Ic value
Earthquake magnitude \( M_b \): 6.60
Peak ground acceleration: 0.53
Depth to water table (insitu): 50.00 ft
Depth to water table (erthq.): 0.53
Average results interval: 1
Ic cut-off value: 2.60
Unit weight calculation: Based on SBT
Use fill: No
Fill height: N/A
Fill weight: N/A
Transition detect. applied: Yes
K_\sigma applied: Yes
Clay like behavior applied: Sands only
Limit depth applied: No
Limit depth: N/A

F.S. color scheme
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

Vertical settlements

Lateral displacements

FS Plot
- Factor of safety
- Depth (ft)

LPI
- Liquefaction potential
- Depth (ft)

CRR plot
- Depth (ft)

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Project file: U:\2017\17-176-00 Terraces Apartments Geotechnical Investigation\Analyses\Liquefaction\CLIQ_TERRACE APTS.clq
Input parameters and analysis data

Fines correction method: NCEER (1998)
Points to test: Based on Ic value
Earthquake magnitude Mw: 6.60
Peak ground acceleration: 0.53

Use fill: No
Fill height: N/A
Fill weight: N/A
Limit depth applied: No
Trans. detect. applied: Yes
Kσ applied: Yes

CPT file: CPT-03

Project title: Terrace Apartments Expansion
Location: Orange, CA

Summary of liquefaction potential

Zone A1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

FS Plot
Factor of safety

CRR plot
CRR & CSR

SBTn Plot
Ic (Robertson 1990)

Cone resistance
Friction Ratio

Mw=7/2, sigma' = 1 atm base curve

Liquefaction
Cyclic Stress Ratio* (CSR*)

Normalized CPT penetration resistance
Normalized friction ratio (%)

CLiq v.2.1.6.11 - CPT Liquefaction Assessment Software - Report created on: 11/17/2017, 8:27:58 AM
Project file: U:\2017\17-176-00 Terraces Apartments Geotechnical Investigation\Analyses\Liquefaction\CLIQ_TERRACE APTS.clq
Liquefaction analysis overall plots

Input parameters and analysis data

- Fines correction method: NCEER (1998)
- Points to test: Based on Ic value
- Earthquake magnitude $M_\text{w}$: 6.60
- Peak ground acceleration: 0.53
- Depth to water table (in situ): 90.00 ft
- Depth to water table (earthq.): 50.00 ft
- Average results interval: 1
- Ic cut-off value: 2.60
- Unit weight calculation: Based on SBT
- Use fill: No
- Fill height: N/A

F.S. color scheme:
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

LPI color scheme:
- Very high risk
- High risk
- Low risk

Factor of safety
Liquefaction potential
Settlement (in)
Displacement (in)
Input parameters and analysis data

- **Analysis method:** NCEER (1998)
- **Fines correction method:** NCEER (1998)
- **Points to test:** Based on Ic value
- **Earthquake magnitude $M_w$:** 6.60
- **Peak ground acceleration:** 0.53
- **Use fill:** No
- **Fill height:** N/A
- **Fill weight:** N/A
- **Limit depth applied:** No
- **Limit depth:** N/A
- **Trans. detect. applied:** Yes
- **$K_p$ applied:** Yes
- **Unit weight calculation:** Based on SBT
- **Method based:** MSF method: Method based
- **Sands only:** Yes
- **Fill height:** 90.00 ft
- **G.W.T. (in-situ):** 50.00 ft
- **G.W.T. (earthq.):** 90.00 ft
- **Ic cut-off value:** 2.60
- **Ic value:** Based on Robertson 1990
- **SBTn Plot**
- **CRR plot**
- **FS Plot**

---

Zone A1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

**Summary of liquefaction potential**

- **Cyclic Stress Ratio (CSR)**
- **Normalized CPT penetration resistance**
- **Normalized friction ratio (%)**
CPT basic interpretation plots (normalized)

**Norm. cone resistance**

**Norm. friction ratio**

**Norm. pore pressure ratio**

**SBTn Plot**

**Norm. Soil Behaviour Type**

---

Input parameters and analysis data:

- **Analysis method:** NCEER (1998)
- **Fines correction method:** NCEER (1998)
- **Points to test:** Based on Ic value
- **Earthquake magnitude Mw:** 6.60
- **Peak ground acceleration:** 0.53
- **Depth to water table (insitu):** 90.00 ft

- **Depth to water table (erthq.):** 50.00 ft
- **Fill weight:** N/A
- **Transition detect. applied:** Yes
- **Kσ applied:** Yes
- **Clay like behavior applied:** Sands only
- **Limit depth applied:** No
- **Limit depth:** N/A

SBTn legend:

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty clay
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravelly sand to sand
8. Very stiff sand to clay
9. Very stiff fine grained
**Input parameters and analysis data**

**Analysis method:** NCEER (1998)

**Fines correction method:** NCEER (1998)

**Points to test:** Based on Ic value

**Earthquake magnitude Mw:** 6.60

**Peak ground acceleration:** 0.53

**Depth to water table (insitu):** 90.00 ft

**Depth to water table (earthq.):** 50.00 ft

**Average results interval:** 1

**Ic cut-off value:** 2.60

**Unit weight calculation:** Based on SBT

**Use fill:** No

**Fill height:** N/A

**Fill weight:** N/A

**Transition detect. applied:** Yes

**Kσ applied:** Yes

**Clay like behavior applied:** Sands only

**Limit depth applied:** Yes

**Limit depth:** N/A

**Almost certain it will liquefy**

**Very likely to liquefy**

**Liquefaction and no liq. are equally likely**

**Unlike to liquefy**

**Almost certain it will not liquefy**

**Almost certain it will not liquefy**

**F.S. color scheme**

**LPI color scheme**

- **Very high risk**
- **High risk**
- **Low risk**

---

**CLiq v.2.1.6.11 - CPT Liquefaction Assessment Software - Report created on: 11/17/2017, 8:27:59 AM**

**Project file:** U:\2017\17-176-00 Terraces Apartments Geotechnical Investigation\Analyses\Liquefaction\CLIQ_TERRACE APTS.clq
Project title: Terrace Apartments Expansion
Location: Orange, CA

CPT file: CPT-05

Input parameters and analysis data

- Fines correction method: NCEER (1998)
- Earthquake magnitude Mw: 6.60
- Peak ground acceleration: 0.53
- Points to test: Based on Ic value
- Average results interval: 1
- Use fill: No
- Fill height: N/A
- Fill weight: N/A
- Trans. detect. applied: Yes
- Limit depth: N/A
- Kσ applied: No
- Limit depth applied: Yes
- MSF method: Method based

Earthquake magnitude Mw:
- Based on Ic value: Ic cut-off value: 2.60
- Unit weight calculation: Based on SBT

Cone resistance

Friction Ratio

SBTn Plot

CRR plot

FS Plot

Summary of liquefaction potential

Zone A1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry
**CPT basic interpretation plots**

### Cone resistance

- **Depth (ft):** 74, 72, 70, 68, 66, 64, 62, 60, 58, 56, 54, 52, 50, 48, 46, 44, 42, 40, 38, 36, 34, 32, 30, 28, 26, 24, 22, 20, 18, 16, 14, 12, 10, 8, 6, 4, 2, 0

### Friction Ratio

- **Depth (ft):** 74, 72, 70, 68, 66, 64, 62, 60, 58, 56, 54, 52, 50, 48, 46, 44, 42, 40, 38, 36, 34, 32, 30, 28, 26, 24, 22, 20, 18, 16, 14, 12, 10, 8, 6, 4, 2, 0

### Pore pressure

- **Depth (ft):** 74, 72, 70, 68, 66, 64, 62, 60, 58, 56, 54, 52, 50, 48, 46, 44, 42, 40, 38, 36, 34, 32, 30, 28, 26, 24, 22, 20, 18, 16, 14, 12, 10, 8, 6, 4, 2, 0

### SBT Plot

- **Soil Behaviour Type**
  - Organic soil
  - Clay & silty clay
  - Clay & silty clay
  - Clay & silty clay
  - Silty sand & sandy silt
  - Clay & silty clay
  - Clay & silty clay
  - Clay & silty clay
  - Clay & silty clay
  - Clay & silty clay
  - Clay & silty clay
  - Clay & silty clay
  - Clay & silty clay
  - Clay & silty clay
  - Clay & silty clay
  - Clay & silty clay
  - Clay & silty clay
  - Clay & silty clay
  - Clay & silty clay
  - Clay & silty clay
  - Clay & silty clay
  - Clay & silty clay

---

**Input parameters and analysis data**

- **Analysis method:** NCEER (1998)
- **Fines correction method:** NCEER (1998)
- **Points to test:** Based on Ic value
- **Earthquake magnitude Mw:** 6.60
- **Peak ground acceleration:** 0.53 g

**Depth to water table:**
- Earthquake (in situ): 50.00 ft
- Earthquake (erthq.): 90.00 ft
- Fill height: N/A

**Fill weight:** N/A

**Transition detect. applied:** Yes

**Kc applied:** Yes

**Sands only:** No

**Limit depth applied:** Yes

---

**SBT legend**

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty clay
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to clay
9. Very stiff fine grained
Liquefaction analysis overall plots

Input parameters and analysis data

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<td>F.S. color scheme</td>
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<tr>
<td>LPI color scheme</td>
<td></td>
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F.S. color scheme
- Red: Almost certain it will liquefy
- Orange: Very likely to liquefy
- Green: Liquefaction and no liq. are equally likely
- Yellow: Unlike to liquefy
- Pale yellow: Almost certain it will not liquefy

LPI color scheme
- Red: Very high risk
- Orange: High risk
- Green: Low risk

Vertical settlements

Lateral displacements
LIQUEFACTION ANALYSIS REPORT

Project title: Terrace Apartments Expansion
CPT file: CPT-06
Location: Orange, CA

Input parameters and analysis data

- Fines correction method: NCEER (1998)
- Points to test: Based on Ic value
- Earthquake magnitude Mw: 6.60
- Peak ground acceleration: 0.53
- Use fill: No
- Fill height: N/A
- Fill weight: N/A
- Trans. detect. applied: Yes
- Kσ applied: Yes
- Limit depth applied: No
- MSF method: Method based

Summary of liquefaction potential:
- Zone A1: Cyclic liquefaction likely depending on size and duration of cyclic loading
- Zone A2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
- Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
- Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

CPT file: U:\2017\17-176-00 Terraces Apartments Geotechnical Investigation\Analyses\Liquefaction\CLIQ_TERRACE APTS.clq
LIQUEFACTION ANALYSIS REPORT

Project title: Terrace Apartments Expansion  
Location: Orange, CA

Input parameters and analysis data

- Fines correction method: NCEER (1998)
- Earthquake magnitude $M_w$: 6.0
- Peak ground acceleration: 0.53
- $I_c$ cut-off value: 2.60
- Unit weight calculation: Based on SBT
- Trans. detect. applied: Yes
- $K_s$ applied: Yes
- MSF method: Method based
- $\mu_w = 7^{1/2}$, $\sigma'$ = 1 atm base curve

Summary of liquefaction potential

Zone A1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry
Liquefaction analysis overall plots

Input parameters and analysis data

Fines correction method: NCEER (1998)
Points to test: Based on Ic value
Earthquake magnitude Mw: 6.60
Peak ground acceleration: 0.53
Depth to water table (in situ): 90.00 ft

Depth to water table (earthq.): 50.00 ft
Average results interval: 1
Ic cut-off value: 2.60
Unit weight calculation: Based on SBT
Use fill: No
Fill height: N/A

Fill weight: N/A
Transition detect. applied: Yes
Transition detect. applied: Yes

Kσ applied: Sands only
Clay like behavior applied: Yes
Limit depth applied: No
Limit depth applied: No

Liquefaction potential

Almost certain it will liquefy
Very likely to liquefy
Liquefaction and no liq. are equally likely
Unlike to liquefy
Almost certain it will not liquefy

Vertical settlements

Settlement (in)

Depth (ft)

Lateral displacements

Displacement (in)

Depth (ft)

CRR plot

CRR & CSR

Factor of safety

LPI

Liquefaction potential

LPI color scheme

Vertical settlements

Lateral displacements

F.S. color scheme

Almost certain it will liquefy
Very likely to liquefy
Liquefaction and no liq. are equally likely
Unlike to liquefy
Almost certain it will not liquefy

CLiq v.2.1.6.11 - CPT Liquefaction Assessment Software - Report created on: 11/17/2017, 8:28:02 AM
Project file: U:\2017\17-176-00 Terraces Apartments Geotechnical Investigation\Analyses\Liquefaction\CLIQ_TERRACE APTS.clq
APPENDIX D

Percolation Test Result
**Riverside/Orange County - Percolation Rate Conversion**

**Porchet Method, aka Inverse Borehole Method**

**Project Name:** Terraces Apartments - Orange, CA  
**Project Number:** 17-176-00

**Test Hole Number:** DH-8  
**Test Hole Radius:** 4 inches  
**Total Depth:** 62.4 inches

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<th>$\Delta t$</th>
<th>Total Time</th>
<th>Initial Depth of Water ($D_0$)</th>
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<th>Initial Height of Water ($H_0$)</th>
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Average Infiltration Rate (in/hour) 4.34

**DH-8 Infiltration Rate vs. Time**

**DH-8 Water Level Drop vs. Time**
## Test Information

**Project Name:** Terraces Apartments - Orange, CA  
**Project Number:** 17-176-00  
**Test Hole Number:** DH-9  
**Test Hole Radius:** 4 inches  
**Total Depth:** 132.0 inches

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**Average Infiltration Rate (in/hour):** 3.86

![DH-9 Infiltration Rate vs. Time](image)

![DH-9 Water Level Drop vs. Time](image)
Riverside/Orange County - Percolation Rate Conversion
Porchet Method, aka Inverse Borehole Method

Project Name: Terraces Apartments - Orange, CA
Project Number: 17-176-00
Test Hole Number: DH-10
Test Hole Radius: 4 inches
Total Depth: 128.4 inches

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Average Infiltration Rate (in/hour) 20.01

DH-10 Infiltration Rate vs. Time

DH-10 Water Level Drop vs. Time
### Project Information

**Project Name:** Terraces Apartments - Orange, CA  
**Project Number:** 17-176-00  
**Test Hole Number:** DH-10  
**Test Hole Radius:** 4 inches  
**Total Depth:** 128.4 inches

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**Average Infiltration Rate (in/hour):** 20.01

### Graphs

**DH-10 Infiltration Rate vs. Time**

**DH-10 Water Level Drop vs. Time**
E-2: Preliminary Addendum Geotechnical Foundation Recommendations
August 1, 2018

Mr. Sidh Solanki
DOMINO REALTY MANAGEMENT CO.
9990 Santa Monica Boulevard
Beverly Hills, CA 90212

GMU Project No.: 17-176-01

Subject: Preliminary Addendum Geotechnical Foundation Recommendations, Addition at Terrace Apartments, 200 City Boulevard West, Orange, California


Dear Mr. Solanki:

Per your request and authorization, GMU Geotechnical, Inc. (GMU) has prepared this preliminary addendum letter to the above-reference geotechnical report in order to provide revised geotechnical recommendations for design and construction of the proposed apartment buildings. We understand per our correspondence with Van Tilburg, Banvard & Soderbergh and review of the above-referenced architectural plans that the design for the proposed apartment buildings within Site A, B and C has changed from a two-level subterranean parking structure to a three-level subterranean parking structure, with a basement depth ranging from approximately 35 to 39 feet below the existing grade. Based on this information, we have performed additional engineering analysis to provide revised geotechnical recommendations as presented in the following sections.

GENERAL SITE PREPARATION AND GRADING

General

The following recommendations pertain to any required grading associated with the proposed improvements and corrective grading needed to support the proposed improvements. All site preparation and grading should be performed in accordance with the City of Orange grading code requirements and the recommendations presented in this report.

Clearing and Grubbing

All significant organic material such as weeds, brush, tree branches, or roots, or construction debris such as old irrigation lines, asphalt concrete, and other decomposable material should be
removed from the area to be graded. No rock or broken concrete greater than 6 inches in diameter should be utilized in the fills.

Corrective Grading

Remedial grading will serve to create a firm and workable platform for construction of the proposed new 4-story apartment buildings.

It should be noted that the recommendations provided herein are based on a limited subsurface exploration and knowledge of the on-site geology. Actual removals may vary in configuration and volume based on observations of geologic materials and conditions encountered during grading. The bottom of all remedial grading removals should be observed by a GMU representative to verify the suitability of in-place soil prior to performing scarification and recompaction. Remedial grading recommendations are outlined below.

Subterranean Building Pad (Site A&B): In order to create a firm and stable platform on which to construct the new subterranean structures foundations within Site A and B apartment buildings, we recommend the following:
  o The subterranean site A and B building pads should be excavated to a depth of at least 3 feet below the bottom of the foundation.
  o The bottom of the over excavation should then be scarified to a depth of at least 6 inches, moisture conditioned to 2% above optimum moisture content and recompacted to at least 90% relative compaction as determined in accordance with ASTM D1557.
  o Following the approval of the over-excavation bottom by a representative of GMU, the onsite material may be used as fill material to achieve the planned pad grade.
  o The fill material should then be placed in 6- to- 8-inch-thick lifts, moisture conditioned to 2% above optimum moisture content and compacted to achieve 90% relative compaction.

Subterranean Building Pad (Site C): In order to create a firm and stable platform on which to construct the new subterranean structures foundations within Site C apartment building, we recommend the following:
  o The subterranean Site C building pads should be excavated to a depth of at least 1 foot below the bottom of the foundation.
  o The bottom of the over excavation should then be scarified to a depth of at least 6 inches, moisture conditioned to 2% above optimum moisture content and recompacted to at least 90% relative compaction as determined in accordance with ASTM D1557.
  o Following the approval of the over-excavation bottom by a representative of GMU, the onsite material may be used as fill material to achieve the planned pad grade.
The fill material should then be placed in 6- to 8-inch-thick lifts, moisture conditioned to 2% above optimum moisture content and compacted to achieve 90% relative compaction.

Additionally, we anticipate to encounter unstable clay material at the pad elevation of the proposed subterranean parking structures. If unstable/saturated soils are encountered at the bottom of the excavation, the unstable soil may be mitigated by performing the following:

- Upon reaching the bottom of the over-excavation, the relatively soft subgrade should be kept relatively undisturbed (with very limited heavy equipment driving over it).
- A blanket of approximately 24 inches of Crushed Aggregate Base (CAB) should be placed over the relatively undisturbed bottom. The thickness of the CAB will depend on the amount of CAB to create a stable platform, however, it is not anticipated to exceed 24 inches.
- The lower foot of CAB should be placed in a 6-to-8-inch-thick lift and compacted to 90 percent relative compaction.
- The final 12 inches of CAB should also be placed in a 6-to-8-inch-thick lift and compacted to 95 percent relative compaction and the top of the 24 inches of CAB should be proof rolled under the observation of a representative of GMU.
- If the 24 inches of CAB are deemed stable by GMU, the engineered fill to reach the final pad grade may consist of onsite sandy soils, placed in 6- to 8-inch-thick lifts, moisture conditioned to optimum moisture content, and compacted to 90 percent relative compaction.
- A representative of GMU should observe the excavation bottom prior to utilizing this mitigation method.

If the subterranean buildings foundation elements are supported by Geopier or equivalent ground improvement system, then the proposed buildings slab-on-grade should be supported on 24 inches of engineered fill.

**FOUNDATION DESIGN AND CONSTRUCTION – SUBTERRANEAN LEVELS**

**General**

The criteria contained in the following section may be used for the design and construction of the proposed apartment building subterranean foundation. We have developed recommendations for a conventional spread/continuous footings system based on the following:

- Based on our review of the updated reference architectural plans, it is our understanding that three (3) four-story apartment buildings will be supported on three-levels of subterranean parking structure.
Mr. Sidh Solanki, DOMINO REALTY MANAGEMENT CO.

*Preliminary Addendum Geotechnical Foundation Recommendations, Addition at The Terrace Apartments, 200 City Boulevard West, Orange, California*

- The bottom proposed subterranean parking structures within Site A & B are anticipated to be situated at a depth of approximately 28 to 33 feet below the existing grade, with a difference in elevation between the two ends of the building on the order of 5 feet.
- The bottom proposed subterranean parking structure within Site C is anticipated to be situated at a depth of approximately 35 to 39 feet below the existing grade, with a difference in elevation between the two ends of the building on the order of 4 feet.
- Based on our field exploration, we have encountered a moist to very moist clay layer at depth of approximately 30 feet below the existing grade.
- Our shallow spread/continuous footings foundation system recommendations incorporate a three (3) feet corrective grading below bottom of footings for Site A & B buildings and a one (1) foot corrective grading below bottom of footings for Site C building.
  - Preliminary loading conditions were provided by the project architect and consist of 650 kips column load (dead plus live) and wall load of 15 kips per lineal feet (dead plus live).
  - If the maximum column load is greater than 650 kips and if there is a need for an increase in bearing capacity while limiting the associated settlement, we recommend that the proposed below-grade structures be supported by either a mat foundation system or shallow conventional spread/continuous foundation system with ground improvement such as Geopiers or equivalent systems. A ground improvement such as Geopiers or equivalent may be beneficial to eliminate the overexcavation below the foundations and reduce the shoring height. General Geopier recommendations are presented in our referenced geotechnical report.

**General Foundation Design Parameters – Conventional Spread/Continuous Footings**

Shallow spread/continuous footings foundation system recommendations provided in this section are based on corrective grading performed below the bottom of footings as discussed previously in the *Corrective Grading* section. The design parameters are presented below may be used for foundation structural design.

- **Bearing Material**: Engineered Fill
- **Removal and Re-compaction Depth**: 3 feet below bottom of footings for Site A & B, and 1 foot below bottom of footing for Site C.
- **Minimum Footing Size**:
  - Width: 24 inches
  - Depth: 24 inches embedment below lowest adjacent soil grade (depth)
- **Allowable Bearing Capacity**: 4,000 psf for the minimum footing size given above.
  - May be increased by 300 psf for each additional foot of footing depth and by 150 psf for each additional foot of footing width to a maximum of 5,000 psf
Above value may be increased by 1/3 for temporary loads such as wind or seismic

o Settlement:
  ▪ Static Settlement:
    • Total: 1.0 inch
    • Differential: 0.5 inches over a span of 40 feet

o Lateral Foundation Resistance:
  ▪ Allowable passive resistance: 200 psf/ft (disregard upper 6 inches, max 2,000 psf)
  ▪ Allowable friction coefficient: 0.30
  ▪ Above values may be combined without reduction and may be increased by 1/3 for temporary loads such as wind or seismic

The allowable bearing capacity may be increased up to 6,000 to 7,000 psf if foundations are supported on Geopiers.

LIMITATIONS

All parties reviewing or utilizing this addendum report should recognize that the findings, conclusions, and recommendations presented represent the results of our professional geological and geotechnical engineering efforts and judgments. Due to the inexact nature of the state of the art of these professions and the possible occurrence of undetected variables in subsurface conditions, we cannot guarantee that the conditions actually encountered during grading and foundation installation will be identical to those observed and sampled during our study or that there are no unknown subsurface conditions which could have an adverse effect on the use of the property. We have exercised a degree of care comparable to the standard of practice presently maintained by other professionals in the fields of geotechnical engineering and engineering geology, and believe that our findings present a reasonably representative description of geotechnical conditions and their probable influence on the grading and use of the property.

Because our conclusions and recommendations are based on a limited amount of current and previous geotechnical exploration and analysis, all parties should recognize the need for possible revisions to our conclusions and recommendations during grading of the project. Additionally, our conclusions and recommendations are based on the assumption that our firm will act as the geotechnical engineer of record during grading of the project to observe the actual conditions exposed, to verify our design concepts and the grading contractor's general compliance with the project geotechnical specifications, and to provide revised conclusions and recommendations should subsurface conditions differ significantly from those used as the basis for our conclusions and recommendations presented in this report.

This report has not been prepared for use by other parties or projects other than those named or described herein. This report may not contain sufficient information for other parties or other purposes.
Mr. Sidh Solanki, DOMINO REALTY MANAGEMENT CO.
Preliminary Addendum Geotechnical Foundation Recommendations, Addition at The Terrace Apartments, 200 City Boulevard West, Orange, California

CLOSURE

We are pleased to present this preliminary addendum geotechnical foundation recommendations for this project. If you have any questions concerning our findings or recommendations, please do not hesitate to contact us and we will be happy to discuss them with you.

Respectfully submitted,

GMU GEOTECHNICAL, INC.

Nadim Sunna, M.Sc., PE
Project Geotechnical Engineer

Reviewed By:

S. Ali Bastani, Ph.D., PE, GE 2458
Director of Engineering

ns/Preliminary Addendum Geotechnical Recommendations (8-1-18)